00088186

THE
ASIATIC SOCIETY OF BOMBAY
Town Hall, Bombay.

Digitized with financial assistance from the
Government of Maharashtra
on 04 April, 2016

Personal Narrative

OF TRAVELS

TO THE

EQUINOCTIAL REGIONS

OF THE

NEW CONTINENT,

DURING THE YEARS 1799—1804,

BY

ALEXANDER DE HUMBOLDT,

AND

AIMÉ BONPLAND;

B.1245 88186

WITH MAPS, PLANS, &c.

WRITTEN IN FRENCH BY

ALEXANDER DE HUMBOLDT,

AND TRANSLATED INTO ENGLISH BY

HELEN MARIA WILLIAMS.

VOL. VI. PART II.

ΣΑ - C - 1

LONDON:

PRINTED FOR LONGMAN, REES, ORME, BROWN, AND GREEN,

PATERNOSTER ROW.

1826.

918
Illim/Per
88186

W. Pople, Printer, 67, Chancery Lane.

CONTENTS

OF VOL. VI. PART II.

PAGE

Sketch of a Geognostic View of South America, on the North of the River of the Amazons, and on the East of the Meridian of the Sierra Nevada de Merida - - - - - - - - - - 391

SECTION I.

Configuration of the Country.—Inequalities of the Soil. Chains and Groups of Mountains.—Ridges of Partition.—Plains or Llanos - - - - - - 393

SECTION II.

General Partition of Lands.—Direction and Inclination of the Layers.—Relative Height of the Formations above the Level of the Ocean - - - 575

SECTION III.

Nature of the Rocks.—Relative Age and Superposition of the Formations.—Primitive, transition, secondary, tertiary, and volcanic Soils - - - 597

1. Co-ordinate Formations of Granite, Gneiss and Micaslate - - - - - - - - 600
2. Formation of Clayey-slate (Thonschiefer) of Malpasso - - - - - - - - - 613
3. Formation of Serpentine and Diorite (Greenstone of Juncalito) - - - - - - - - 615
4. Granular and micaceous Limestone of the Morros of San Juan - - - - - - - - 616

PAGE
5. Felspathic Sandstone of the Oroonoko - - 617
6. Formation of the Sandstone of the Llanos of Calabozo - - - - - - - - - 618
7. Formation of compact Limestone of Cumanacoa - 624
8. Formation of compact Limestone of Caripe - 626
9. Sandstone of Bergantin - - - - - - 429
10. Gypsum of the Llanos of Venezuela - - 630
11. Formation of Muriatiferous Clay (with Bitumen and Lamellar Gypsum) of the Peninsula of Araya 632
12. Agglomerate Limestone of Barigon, the Castle of Cumana, and the Vicinity of Porto Cabello - - 638
13. Formation of Pyroxenic Amygdaloide and Phonolite, between Ortiz and Cerro de Flores - - 642
Observations made to verify the progress of the Horary Variations of the Barometer in the Tropics, from the Level of the Sea to the Ridge of the Cordillera of the Andes - - - - - - - - 662
Mean Height of the Barometer in the Tropics, at the Level of the Sea - - - - - - - 773
Mean Temperature of Cumana.—Hygrometric and Cyanometric State of the Air - - - - 777
I. Observations of M. De Humboldt - - 781
II. ———— Don Faustino Rubio - - 793
Additional Note on the Height of the Lake of Nicaragua above the Level of the Sea - - - 797

BOOK X.

CHAPTER XXVII.

Passage from the Coast of Venezuela to the Havannah. —General View of the Population of the West Indies, compared with the Population of the New Continent, with respect to the Diversity of Races, Personal Liberty, Language, and Worship - - 801

SKETCH OF A GEOGNOSTIC VIEW

OF

SOUTH AMERICA,

On the North of the River of the Amazons, and on the East of the Meridian of the Sierra Nevada de Merida.

THE object of this memoir is to concentrate the geognostic observations which I was enabled to collect in the course of my journeys among the mountains of New Andalusia, and Venezuela, on the banks of the Oroonoko, and in the *Llanos* of Barcelona, Calabozo, and the Apure; consequently, from the coast of the Caribbean sea, to the valley of the Amazons, between the parallels of 2° and 10½° north latitude. In describing objects as they successively appear to the traveller, every fact remains insulated; he relates what he has seen in following the windings of roads, and a knowledge is thus acquired of the succession of formations in such or such a direction; but we cannot seize their mutual connexion. The order of ideas to which the personal narrative of a journey should be restrained, has the advantage of

making us distinguish more easily what is the result of a direct observation, or that of a combination founded on analogy; but in order to comprehend in one point the geognostic view of a vast part of the globe, and contribute to the progress of geognosy, which is a science of connexion, we must relinquish the sterile accumulation of insulated facts, and study the relations that exist between the inequalities of soil, the direction of the Cordilleras, and the mineralogical nature of the territory.

I passed through an extent of country in different directions, of more than 15,400 square leagues. It has already been the object of a geognostic sketch, traced hastily on the spot, after my return from the Oroonoko, and published in 1801, by M. de Lametherie in the *Journal de Physique* (Vol. xlv, p. 46). At that period, the direction of the Cordillera on the coast of Venezuela, and the existence of the Cordillera of Parime, were not known in Europe. No measure of height had been attempted beyond the province of Quito; no rock of South America had been named; no description existed of the *superposition of rocks*, in any region of the tropics. In such circumstances, an essay tending to prove *the identity of the formations of the two hemispheres*, could not fail to excite the interest of geognosts. The study of the collections that I brought back, and four years

of journeying in the Andes, have enabled me to rectify my first views, and to extend an investigation which, on account of its novelty, had been favorably received. The mineralogical descriptions of every rock have been given in the preceding chapters; it now only remains to collect the scattered materials, and mark the pages where the detail of the observations are found. That the most remarkable geognostic relations may be more easily seized, I shall treat in an aphoristic manner, in different sections, the configuration of the soil, the general division of the land, the direction and inclination of the beds, and the nature of the primitive, intermediary, secondary, and tertiary rocks. The nomenclature I employ in this memoir, is that of which I recently stated the principles in a work on general geognosy *.

SECTION I.

Configuration of the Country.—Inequalities of the Soil.—Chains and groups of Mountains.—Ridges of Partition.—Plains or Llanos.

South America is one of those great triangular masses which form the three continental

* See my *Essay on the position of Rocks in the two Hemispheres*, 1823.

parts of the southern hemisphere of the globe. It resembles Africa more in its exterior configuration than New Holland. The southern extremities of the three continents are so placed, that in crossing from the Cape of Good Hope (lat. 33° 55′) to Cape Horn (lat. 55° 58′) and doubling the south point of Van Diemen's land, (lat. 43° 38′), we see those extremities stretching on towards the south-pole in proportion as we advance towards the east. A fourth part of the 571,000 square marine leagues * which South America contains, is covered with mountains distributed in chains, or accumulated in groups. The rest are plains forming long uninterrupted bands covered with forests or gramina, flatter than in Europe, and rising progressively, at 300 leagues distance from the coast, from 30 to 170 toises above the level of the Ocean. (See above, Vol. iv, p. 310; and v, 250.) The most considerable chain of South America extends from south to north, according to the greatest dimension of the continent; it is not central as in Europe, nor far removed from the sea-shore, like Himalaya and Hindoo-Koh; but thrown towards the western extremity of the continent, almost on the coast of the Pacific Ocean. In fixing the eye on the

* Almost the double of Europe, *See* above, p. 336.

profile which I have given * of the configuration of South America, under the parallel of Chimborazo and Grand Para, across the plains of the Amazon, we saw the land low towards the east, in a talus, like an inclined plane, under an angle of less than 25 seconds, on a length of 600 marine leagues. If, in the ancient state of our planet, the Atlantic Ocean, by some extraordinary cause, ever rose to 1100 feet above its present level (a height one-third less than the interior table-lands of Spain and Bavaria), the waves must have broken in the province of Jaen de Bracamoros, against the rocks that bound the eastern declivity of the Cordilleras of the Andes. The rising of this ridge is so inconsiderable compared to the whole continent, that its breadth in the parallel of the Cape of Saint-Roch is 1400 times greater than the mean height of the Andes.

We distinguish in the mountainous part of South America, a chain and three groups of

* *Map of Columbia, according to the astronomical observations of M. de Humboldt, by A. H. Bruè,* 1823, to which are joined the profiles of the Cordilleras and the plains. In tracing an outline by the parallel of 5° south latitude, from Jaen de Bracamoros, as far as Cape Saint-Roch, in the greatest breadth of South America from west to east, we find 880 leagues, or a regular slope of $\frac{1}{76}$ feet in the league of 17,130 *pieds de roi*, or of 5 $\frac{3}{10}$ inch in the mile of 951 toises. (*See* Vol. iv, p. 454.)

mountains, namely, the Cordillera of the Andes, which the geognost may follow without interruption, from Cape Pilares, in the western part of the strait of Magellan, to the promontory of Paria, opposite the island of Trinidad; the insulated group of the *Sierra Nevada de Santa Marta*, the group of the *Mountains of the Oroonoko*, or of *la Parime*, and that of the *Mountains of Brazil*. The Sierra de Santa Marta being nearly in the meridian of the Cordilleras of Peru and New-Grenada, navigators fell commonly into the error of supposing the snowy summits which they descry in passing the mouth of the Rio Magdalena, to be the northern extremity of the Andes. I shall soon prove that the colossal group of the Sierra de Santa Marta is almost entirely separate from the mountains of Ocaña and Pamplona, which belong to the eastern Cordillera of New Grenada. The hot plains through which runs the Rio Cesar, and which extend towards the valley of Upar, separate the Sierra Nevada from the Paramo de Cacota, south of Pamplona. The ridge which divides the waters between the gulph of Maracaybo and the Rio Magdalena, is in the plain on the east of the Laguna Zapatoza. If the Sierra de Santa Marta has long been erroneously considered, on account of its eternal snows, and its longitude, to be a continuation of the Cordilleras of the Andes, the connexion on the other

hand, of that very Cordillera with the mountains on the coast of the provinces of Cumana and Caraccas, has not been recognized. The chain of the shore of Venezuela, of which the different ranges form the Montaña de Paria, the isthmus of Araya, the Silla of Caraccas, and the mountains of gneiss-granite north and south of the lake of Valencia, is joined between Portocabello, San Felipe and Tocuyo (by the Torito, the Picacho de Nirgua, the Palomera, and Altar), to the Paramos de las Rosas and Niquitao, which form the north-east extremity of the Sierra de Merida and the eastern Cordillera of the Andes of New Grenada. It is sufficient to have here indicated the connexion, so important in a geognostic point of view; for the denominations of Andes and Cordilleras being altogether in disuse for the chains of mountains which stretch from the eastern gulph of Maracaybo to the promontory of Paria, we shall continue to designate those chains, stretching from west to east, by the names of the *chain of the shore*, or *coast-chain of Venezuela.*

One of those insulated groups of mountains, that is, of those which are not branches of the Cordillera of the Andes and its continuation towards the shore of Venezuela, is on the north, and the other two west of the Andes; the former is the *Sierra Nevada de Santa Marta*; the two others are the *Sierra de la Parime*, between

4° and 8° of north latitude, and the *Mountains of Brazil*, between 15° and 28° south latitude. This singular distribution of great inequalities of soil produces three plains or basins, that constitute altogether a surface of 420,600 square leagues, or four-fifths of all South America, east of the Andes. Between the *chain of the coast of Venezuela* and the *group of Parime*, *the plains of the Apure and the Lower Oroonoko* extend; between the *group of the Parime*, and that of the *Mountains of Brazil*, the *plains of the Amazon, the Rio Negro, and the Madeira*, and between the *groups of Brazil* and the southern extremity of the continent, the *plains of Rio de la Plata*, and of *Patagonia*. As the group of the Parime in Spanish Guyana, and that of Brazil (or of Minas Geraes and Goyaz), do not join the Cordillera of the Andes of New Grenada and Upper Peru, towards the west, the three plains of the Lower Oroonoko, the Amazon, and the Rio de la Plata, communicate together by land-straits of considerable breadth. These straits are also plains stretching from north to south, and crossed by ridges imperceptible to the eye, but forming *divortia aquarum*. These ridges (and this striking phenomenon has not hitherto fixed the attention of geognosts), these ridges, or *lignes de faites*, are placed between the 2° and 3° of north latitude, and the 16° and 18° of south latitude. The

first ridge forms the partition of the waters which throw themselves into the Lower Orooноko on the north-east, and into the Rio Negro and the Amazon on the south and south-east; the *second ridge* divides the tributary streams of the right bank of the Amazon and the Rio de la Plata. The direction of these *lignes de faites* is such, that if they were marked by the chains of mountains they would unite the group of the Parime to the Andes of Timana (*Pers. Nar.* Vol. v, p. 326), and the mountains of Brazil to the promontory of the Andes of Santa Cruz de la Sierra, Cochabamba, and Potosi. We make a supposition so vague, only that the outline of this vast portion of the globe may be more easily perceived. These risings in the plain, in the intersection of two plains slightly inclined, those two ridges, of which the existence is only manifested, as in Volhinia * by the course of the waters, are parallel to the chain of the coast of Venezuela; they present, it may be said, *two systems of counter-slopes little developed*, in the direction from west to east, between the Guaviare and the Caqueta, and between the Mamori and the Pilcomayo. It is also wor-

* On the partition of the waters between the Dniéper (or the Black Sea), and the Niemen (or the Baltic), *See the hydrographic map of Poland, by MM. Perthes and Komarcewsky*, 1809.

thy of remark, that in the southern hemisphere, the Cordillera of the Andes sends an immense counterpoise towards the east, the promontory of the Sierra Nevada de Cochabamba, whence begins the ridge stretching between the tributary streams of the Madeira and Paraguay towards the lofty group of the mountains of Brazil or Minas Geraes. Three transversal chains (the mountains of the shore of Venezuela, of the Oroonoko, or Parime, and the mountains of Brazil) tend, it may be said, to join the longitudinal chain (the Andes), either by an intermediary group (between the lake of Valencia and Tocuyo) or by ridges formed by the intersection of counter-slopes in the plains. The two extremities of the three Llanos which communicate by land-straits, the Llanos of the Lower Oroonoko, the Amazon, and the Rio de la Plata or of Buenos Ayres, are steppes, covered with gramina, while the intermediary Llanos, that of the Amazon, is a thick forest. With respect to the two land-straits, forming bands directed from north to south (from the Apure to Caqueta across the Provincia de los Llanos, and the sources of the Mamori to Rio Pilcomayo, across the province of Mocos and Chiquitos) they display bare and grassy steppes like the plains of Caraccas and Buenos Ayres.

In the immense space of land east of the Andes, which comprehends more than 480,000

square marine leagues, of which 92,000 are a mountainous country, no groupe rises to the region of perpetual snows; none even attains the height of 1,400 toises. This lowering of the mountains in the eastern region of the New Continent, extends as far as 60° of north latitude; while in the western part, on the prolongation of the Cordilleras of the Andes, the highest summits rise in Mexico (lat. 18° 59′), to 2,770 toises, and in the Rocky Mountains (lat. 37° to 40°) to 1,900 toises. The insulated groupe of the Alleghanies, which corresponds by its eastern position and direction with the groupe of Brazil, does not surpass 1,040 toises*. The lofty summits therefore, exceeding the height of Mont Blanc, belong only to the longitudinal chain that bounds the basin of the Pacific Ocean, from the 55° south to the 68° north, that is to say, the Cordillera of the Andes. The only insulated groupe that can be compared with the snowy summits of the equinoxial Andes, and which attains the height of nearly 3,000 toises, is the Sierra de Santa Marta; it is not placed on the east of the Cordilleras, but between the prolongation of two of their branches, those of Merida and Veragua. The Cordilleras,

* The culminant point of the Alleghanies is Mount Washington, in New Hampshire, lat. 44¼°. According to Captain Partridge it is 6634 English feet.

where they bound the Caribbean sea, in that part which we denote by the name of *Chain of the shore of Venezuela*, do not attain the extraordinary height (2,500 toises) which they reach in their prolongation towards Chita and Merida. In considering separately the groupes of the east, those of the shore of Venezuela, Parime, and Brazil, we see them diminish from north to south. The highest summits of each groupe are the Silla de Caraccas (1350 toises), the peak Duida (1300 toises), the Itacolumi and the Itambe * (900 toises). But, as I have already observed in another place †, it would be an error to judge the height of a chain of mountains solely from that of the most lofty summits. The peak of the Himalaya ‡, most exactly measured, is 676 toises higher than the Chimborazo; the Chimborazo 900 toises higher than Mont Blanc; and Mont Blanc 653 toises higher than the peak Nethou §. These differ-

* According to the measure of MM. Spix and Martins, the Itambe de Villa de Principe is 5590 feet high. (*Martin's Physiognomy of Pflanzenreichs in Brazilien*, 1824, p. 23.)

† See my first memoir on the mountains of India, in the *Annales de chimie et de physique*, 1816, Vol. iii, p. 313.

‡ The Peak Iewahir, lat. 30° 22′ 19″; long. 77° 35′ 7″ east of Paris. Height 4026 toises, according to MM. Hodgson and Herbert.

§ This peak, called also peak of Anethou or Malahita, or eastern peak of Maladetta, is the highest summit of the Pyrenees. It rises 1787 toises, and consequently exceeds

ences do not furnish the relations of the mean height of the Himalaya, the Andes, the Alps, and the Pyrenees, that is, the height of the *back of the mountains*, on which arise the peaks, needles, pyramids, or rounded domes. It is that part of the back where the *passages* are made, that furnishes a precise measure of the *minimum* of the height attained by the great chains. In comparing the whole of my measures with those of Moorcroft, Webb and Hodgson, Saussure and Ramond, I estimate the *mean height* of the top of the Himalaya, between the meridians of 75° and 77°, at 2450 toises; the Andes * (at Peru, Quito, and New

Mont Perdu 40 toises. (Vidal and Reboul, in the *Annales de chimie*, tom. v, p. 234, and in the *Journal de physique*, 1822, Dec. p. 418, *Charpentier, Essai sur la constit. géognost. des Pyrénées*, p. 823, 539.)

* In the passage of Quindiu, between the valley of Magdalena and that of the Rio Cauca, I found the culminant point (la Garita del Parama), at 1798 toises of absolute height; it is however, regarded as one the least elevated. The *passages of the Andes* of Guanacas, Guamani, and Micuipampa are respectively 2300, 1713, and 1817 toises above the surface of the ocean. Even in 33° south latitude, the road which crosses the Andes between Mendoza and Valparaiso is 1987 toises high. *See* my *Astron. Obs.* Vol. i, p. 312, 314, and 316, *Caldas, Semanario de Santa Fe de Bogota*, tom. i, p. 8 and 38. I do not mention the Col de l'Assuay, where I passed, near la Ladera de Cadlud, on a ridge 2428 toises high, because it is a passage on a transversal ridge that joins two parallel chains.

Grenada), at 1850 toises; the top of the Alps and Pyrenees at 1150 toises. The difference of the *mean height* of the Cordilleras (between the parallels of 5° north and 2° south) and the Alps of Switzerland, is consequently 200 toises less than the difference of their loftiest summits; and in comparing the *passages* of the Alps, we see that the mean height of their tops is nearly the same, although the peak Nethou is 600 toises lower than Mont Blanc and Mont Rose. Between Himalaya* and the Andes, on the

* The *passages* of the Himalaya that lead to Chinese Tartary in Hindostan (Nitee-Ghaut, Bamsaru, Chatoulghati, &c.) are from 2400 to 2700 toises of absolute height. With respect to the most elevated top of the Himalaya, I have chosen it among the peaks placed between the meridians of the lake Manasarowar and Balaspore, they only having been measured with great precision by MM. Webb, Hodgson, and Herbert. (*Asiat. Research.* Vol. xiv, p. 187, 373; *Edinb. Phil. Journ.*, 1823, *in*-18, p. 312). We know no measure so precise, says Captain Hodgson, south-east of lat. 30° 22′, and long. 77° 37′. There may be still loftier summits in the meridian of Gorukpur and that of Rungpur; and it has, in fact, been concluded, according to angles taken at very great distances, that the peak of Chamalari, near which Turner passed in going to Tissu-Lumbu, and the peak Dhawalagiri, south of Mustang, near the source of the Gunduck, was 28,077 English feet, (4390 toises) high. (*Journ. of the Roy. Instit.*, 1821, Vol. ii, p. 242.) The measure of Dhawalagiri by Webb, so ably discussed by Mr. Colebroke, was confirmed by Mr. Blake; but, in the table furnished in this memoir, I thought it would be more prudent for the present,

contrary, (considering those chains in the limits which I have just indicated,) the difference between the mean height of the ridges and that of the loftiest summits preserves nearly the same relations. In applying an analogous reasoning to those groupes of mountains which we have made known, at the east of the Andes, we find the mean height of the chain of the shore of Venezuela to be 750 toises; of the Sierra Parime, 500 toises; of the Brazilian groupe, 400 toises; whence it follows that the mountains of the eastern region of South America, are, between the tropics, to the mean elevation of the Andes, in the relation of 1 to 3. The following is the result of some numerical statements, of which the comparison affords more precise ideas on the structure * of mountains in general.

to give the preference to the peak Iewahir, measured by Mr. Herbert. Those measures will be discussed in another place.

* The *necks* or *passages* indicate the *minimum* of the height to which the ridge of the mountains lowers in such or such a country. Now, in casting a look on the principal passages of the Alps of Switzerland, (col de Seigne, 1263 t.; col Terret, 1191 t.; Mont-Cenis, 1060 t.; Petit Saint-Bernard, 1125 t.; Grand Saint-Bernard, 1246 t.; Simplon, 1029 t.; Saint-Gothard, 1065 t.; la Fourche, 1250 t.); and on the neck des *Pyrénées* (Picade, 1243 t.; Benasque, 1231 t.; la Glère, 1196 t.; Pinède, 1291 t.; Gavarnie, 1197 t.; Cavarère, 1151 t.; Tourmalet, 1126 t.); it would be difficult to affirm that the top of the Pyrenees is lower than the mean height of the Swiss Alps. (*Ramond. Voyage au Mont-Perdu,*

NAMES OF THE CHAINS OF MOUNTAINS.	The highest summits.	Mean height of the ridge.	Relation of the mean height of the ridges to that of the highest summits.
Himalaya (between nor. lat. 30° 18′ and 31° 53′, and long. 75° 23′ and 77° 38′).....	4026 t.	2450 t.	1 : 1·6
Cordilleras of the Andes (between lat. 5° nor. and 2° south.....	3350 t.	1850 t.	1 : 1·8
Alps of Switzerland.....	2450 t.	1150 t.	1 : 2·1
Pyrenees.....	1787 t.	1150 t.	1 : 1·5
Chain of the shore of Venezuela.	1350 t.	750 t.	1 : 1·8
Groupe of the mountains of Parime.....	1300 t.	500 t.	1 : 2·6
Groupe of the mountains of Brazil.....	900 t.	400 t.	1 : 2·3

If we distinguish among the mountains those which rise in detached masses, and form small insulated *systems* (the groupes of the Canaries, the Azores, the Sandwich Islands, the Monts Dores, the Euganees), and those that make a part of a continued chain (Himalaya, Alps,

p. 23.) What characterizes the latter chain, is the *relative* height of the summits (that is, the elevation of those summits compared with the top), which is much less in the Pyrenees, in the Andes, and in Himalaya; for even in adopting the measure of Dhawalagiri (4390 t.), we still find for the Himalaya, only the relation of 1 : 1·7.

Andes,) we may observe that, notwithstanding the immense height* of the summits of some insulated systems, the *culminant points of the whole globe* belong to continued chains, to the Cordilleras of central Asia, and South America.

In that part of the Andes with which I am best acquainted, between 8° of south latitude, and 21° of north latitude, all the colossal summits are of trachyte. It may almost be admitted as a general rule, that whenever the mass of mountains rises in that region of the tropics much above the limit of perpetual snows (2300—2470 toises), the rocks vulgarly called primitive (for instance the gneis-granite or micaslate) disappear, and the summits are of trachyte or trapean-porphyry. I know only a few rare exceptions to this law in the Cordilleras of Quito, where the Nevados of Conderasto and Cuvillan, placed opposite the trachytic Chimborozo, are composed of micaslate, and contain veins of sulphurated silver. In the same manner, in the groupes of detached mountains that rise abruptly from the plains, the loftiest summits

* Among the *insulated systems*, or *sporadic mountains*, the Mowna Roa is generally regarded as the most elevated summit of the Sandwich Islands; it is computed at 2500 toises, and is yet at some seasons entirely stript of its snows. (*Personal Nar.* Vol. i, p. 105). An exact measure of this summit, situated in very frequented latitudes, has during 25 years, been claimed in vain by naturalists and geognosts!

(Mowna Roa, Peak of Teneriffe, Etna, Peak of the Azores), furnish only modern volcanic rocks. It would however, be an error to extend that law to every other continent, and to admit in general that, in every zone, the greatest elevations have produced *trachytic domes*; gneis-granite and mica-slate constitude, in the almost insulated groupe of the Sierra Nevada of Grenada, the Peak of Malhacen *, as they also constitute in the continued chain of the Alps, the Pyrenees, and probably the Himalaya †, the summits of the ridge. Perhaps these phenomena, discordant in appearance, are effects of the same cause; perhaps granite, gneiss, and all the pretended *primitive Neptunian mountains*, are owing to volcanic forces, as well as the trachytes; but to forces of which the action resembles less the still burning volcanoes of our days, ejecting lava, which at the moment of its

* This peak, according to the survey of M. Clemente Roxas, is 1826 toises above the level of the sea, consequently 39 toises higher than the loftiest top of the Pyrenees (the granitic peak of Nethou), and 83 toises lower than the trachytic peak of Teneriffe. The Sierra Nevada of Grenada forms a system of mountains of mica-slate, passing to gneis and clay-slate, and which contains shelves of euphotide and green-stone. See the excellent gepgnostic memoir of Don Jose Rodrigues in the *Ann. de Chimie*, Tom. xx, p. 98.

† If we may judge from the specimens of rocks collected in the *necks* and *passages* of the Himalaya, or rolled down by the torrents.

eruption enters immediately into contact with the atmospheric air; but it is not here my purpose to discuss this great theoretic question.

After having examined the general structure of South America according to considerations of *comparative geognosy*, I shall now state separately the *different systems of mountains and plains*, of which the mutual connection has so powerful an influence on the state of industry and commerce of the nations of the New Continent. I shall give only a general view of the systems placed beyond the limits of the region which forms the special object of this memoir. Geology being essentially founded on the study of the relations of juxta-position and place, I could not treat of the chains of the shore and of Parime separately, without touching on the other *systems* placed south and west of Venezuela.

A. *Systems of Mountains.*

a. Cordilleras of the Andes. This is the most continued, the longest, the most constant in its direction from south to north, and north-north-west, of any chain of the globe. It approaches the north and south poles at unequal distances of from 22° to 33°. Its developement is from 2800 to 3000 leagues, (20 to a degree,) a length equal to the distance from Cape Finisterre in Galicia to the north-east Cape (Tschuktschoi-Noss) of Asia. Somewhat less than

the half of this chain belongs to South America, and runs along its western coast. On the north of the isthmus of Cupica and of Panama, after an immense lowering, it assumes the appearance of a nearly central ridge, forming a rocky dyke that joins the great continent of North America to that of the south. The low lands on the east of the Andes of Guatimala and New Spain, appear to have been overwhelmed by the floods, and now form the bottom of the Caribbean Sea. As the continent beyond the parallel of Florida again widens towards the east, the Cordilleras of Durango, and New Mexico, as well as the Rocky Mountains which are a continuation of those Cordilleras, appear to be thrown anew towards the west, that is, towards the coast of the Pacific Ocean; but they still remain eight or ten times more remote from it than in the southern hemisphere. We may consider as the two extremities of the Andes, the rock or granitic isle of Diego Ramirez, south of Cape Horn, and the mountains that reach the mouth * of the Mac-

* I have fixed the longitude of the northern extremity of the chain of the Andes in the *Rocky Mountains*, according to the corrections made recently by Captain Franklin, in Mr. Mackenzie's map. The errors in latitudes 67° and 69°, appear from 4° to 6° longitude; but in the parallel of the Slave Lake they are almost nothing. (Mouth of the Mackenzie river, according to Franklin, 128°; according to Mackenzie,

kenzie river, (lat. 69°, long. 130½°), more than twelve degrees west of the green-stone mountains *, known by the denomination of the *Copper Mountains*, and visited recently by Captain Franklin. The colossal peak of Saint Elia, and that of Mount Fairweather, of New Norfolk, do not belong, properly speaking, to the northern prolongation of the Cordilleras of the Andes, but to a parallel chain (the maritime Alps of the north-west coast), stretching towards the peninsula of California, and connected by transversal ridges with a mountainous land, between the 45° and 53° of latitude, with the Andes of New Mexico *(Rocky Mountains)*. In South America (and my *geognostic table* is particularly restricted to that part of the New Continent), the mean breadth of the Cordillera of the Andes is from 18 to 22

135°: mouth of the Copper-mine river, according to Franklin, 115° 37′; according to Mackenzie and Hearne, 111°: mouth of the Slave River, in the lake of that name, according to Franklin, 112° 45′; according to Mackenzie, 113° *west* of Greenwich). From these statements it results, 1st. that the Rocky Mountains are in the parallel from 60° to 65°, at 124° to 125° long. *west of the meridian of Paris*; 2d. that the northern extremity of the chain, west of the mouth of Mackenzie river, is 130° 20′ of long.; and, 3d. that the groupe of the Copper-Mountains is 118° and 119° long., and 67° and 68° latitude. *Franklin's Journal to the Polar Sea*, p. 638.

* See an excellent geognostic memoir by Mr. Richardson, in Franklin's Journ. page 528.

leagues *. It is only in the *knots of the mountains*, that is, where the Cordillera is swelled by *counter-forts*, or divided into several chains nearly parallel, and that are rejoined at intervals, for instance, on the south of the lake of Titicaca, that it is more than 100 to 120 leagues broad, in a direction perpendicular to its axis. The *Andes of South America* bound the plains of the Oronooko, the Amazon, and the Rio de la Plata towards the west, like a rocky wall (*Crete de filon*) which had been raised across a crevice 1300 leagues long, and stretching from south to north. This heaved up part (if it be permitted to use an expression founded on a *geogonic hypothesis*), comprises a surface of 58,900 square leagues, between the parallel of Cape Pillar, and the northern Choco. In order to form an idea of the variety of rocks which this space may furnish for the observation of the traveller, we must recollect that the Pyrenees, according to the observations of M. Charpentier †, occupy only 768 square marine leagues.

* The breadth of this immense chain is a phenomenon well worthy of attention. The Swiss Alps extend in the Grisons and in the Tyrol, to a breadth of 36 and 40 leagues, both in the meridians of the lake of Como, and the canton Apenzell, and in the meridian of Bassano and Tegernsee.

† Nearly 1200 square leagues of France. See *Essai, sur les Pyrenées*, p. 6.

The name of Andes in the Quichua language (language of the Inca), which wants the consonants *d*, *f*, and *g*, *Antis*, or *Ante*, appears to me to be derived from the Peruvian word *anta*, signifying copper, and metal in general. They also say *anta chacra*, mine of copper; *antacuri*, copper mixed with gold; *puca anta*, copper, or red metal. As the group of the Altai mountains * has taken the denomination in the Turkish dialects of the word *altor* or *altyn*, in the same manner the Cordilleras must have been termed *Copper-country* or *Anti-suyu*, on account of the abundance of metal which the Peruvians employed for their tools. The Inca Garcilasso, son of a Peruvian princess, who wrote with an affecting simplicity the history of his native country in the first years of the conquest †, gives no etymology of the name of the Andes. He only opposes *Anti-suyu*, or the region of summits covered with eternal snows (*ritiseca*), to the plains or *Yuncas*, that is, to the lower region of Peru. I thought that the etymology of the longest chain of the globe would have some interest for the mineralogic geographer.

* *Klaproth, Asia polyglotta*, p. 211. It appears to me less probable that the tribe of the Antis gave its name to the mountains of Peru.

† Basil Hall, Journal in Chili and Peru, 1824, Vol. i, p. 3.

The structure of the Cordillera of the Andes, that is, its disposition in several chains nearly parallel, which are rejoined by *knots of mountains*, is very remarkable. Our maps indicate this structure in the most imperfect manner; and what La Condamine and Bouguer had guessed, during their long stay on the table-land of Quito only, has been generalized and ill-interpreted by those who have described the whole chain according to the type of the equatorial Andes. The following is what I could collect that was most positive by my own researches, and an active correspondence of twenty years with the inhabitants of Spanish America. The group of islands very near each other, vulgarly called Land of Fire, in which the chain of the Andes begins, is a plain from the Cape of Saint Esprit as far as the canal of Saint Sebastian. The country on the west of this canal, between Cape Saint Valentin and Cape Pilares, is bristled with granitic mountains that are covered (from Morro de San Agueda to Cabo Redondo) with calcareous shells. Navigators have greatly exaggerated the height of the mountains of the Land of Fire, among which there appears to be a volcano still burning. M. de Churruca found the western peak of Cape Pilares (lat. 52° 45′ south) only 218 toises *; even Cape Horn is probably not more

* *Relacion del viage al Estrecho de Magellanes. Appendice*, 1793, p. 76.

than 500 toises * high. The plain extends on the northern bank of the strait of Magellan, from the Cape of Virgins, to Cabo Negro; at that Cape the Cordilleras rise abruptly, and fill the whole space as far as Cape Victoria (lat. 52° 22′). The region between Cape Horn and the southern extremity of the continent somewhat resembles the origin of the Pyrenees between Cape Creux (near the gulph of Rosas), and the Col de Pertus. The height of the Patagonian chain is not known; it appears, however, that no summit south of the parallel of 48°, attains the elevation of Canigou (1430 toises), which is placed near the eastern extremity of the Pyrenees. In the southern country, where the summers are so cold and short, the limit of the eternal snows must lower at least as much as in the northern hemisphere, in Norway, in 63° and 64° latitude, consequently below 800 toises †.

* It is very distinctly seen at 60 miles distance, which, without counting the terrestrial refractions, would give it a height of 498 toises.

† I have founded my judgment on the limit of the snows between 48° and 51° in the Patagonian lands, and on the analogy of climate of the Malouine islands (lat. 51° 25′), the only point equally south which we know with precision. The mean temperature of the whole year in the Malouines, (8·3 cent.) corresponds, it is true, with that of Edinburgh (lat. 55° 57′) in the northern hemisphere; but such is the difference of the division of heat, between the different sea-

The great breadth, therefore, of the band of snow that envelopes these Patagonian summits, does not justify the idea formed of their height by travellers, in 40° of south latitude. As we advance towards the Island of Chiloe, the Cordilleras draw near the coast; and the Archipelago of Chonos or Huaytecas appears like the vestiges of an immense group of mountains overwhelmed by the floods. Arms of narrow seas (*esteros*) fill the lower vallies of the Andes, and remind us of the *fiords* of Norway and Greenland. We there find, ranged from south to north *, the *Nevados* de Maca (lat. 45° 19′), of Cuptana (lat. 44° 58′), of Yanteles (lat. 43° 52′) of Corcovado, Chayapirca (lat. 42° 52′) and of Llebcan (lat. 41° 49′). The peak of Cuptana rises like the peak of Teneriffe, from the bosom of the sea; but being scarcely visible at 36 or 40 leagues distance, it cannot be more than

sons, in the two hemispheres, on the same line, that the mean temperature of the summers at Edinburgh is 14° 6′, and at the Malouine islands scarcely 11° 4′. Now, the isotherm line (equal summer) from 11° to 12° passes in our hemisphere, on the eastern coast of Westrobornie, in 64° of latitude, and it is known that these cold summers correspond with a height of perpetual snows, of 750 to 800 toises. *See my memoir on the Isotherm lines*, p. 112.

* Manuscripts and maps of Don Jose de Moraleda. (See also Sir Charles Giesecke in *Scoresby's* voy. to West-Greenland, p. 467.)

1500 toises high. Corcovado, placed on the coast of the continent, opposite the southern extremity of the island of Chiloe, appears to be more than 1950 toises high; it is perhaps, the loftiest summit of the whole globe, *south of the parallel of* 42° *south latitude.* On the north of San Carlos de Chiloe, in the whole length of Chili to the desart of Atacama, the low western regions not having been overwhelmed by the floods, the Andes there appear farther from the coast. The Abbé Molina *, always positive in what is doubtful, affirms that the Cordilleras of Chili, form three parallel chains, of which the intermediary is the most elevated; but to prove that this division is far from general, it suffices to recollect the barometric survey made by MM. Bauza and Espinosa, in 1794, between Mendoza and Santiago de Chili. The road which leads from one of those towns to the other, rises by degrees from 700 to 1987 toises; and after passing the col des Andes (*La Cumbre*, between the houses of refuge called *Las Calaveras* and *Las Cuevas*), it descends continually as far as the temperate valley of Santiago de Chili, of which the bottom is only 409 toises above the level of the Ocean. The same survey has made known to us the *minimum* of

* *Saggio*, p. 4, 38, 48. Compared with the *manuscripts of M. Nee*, botanist of the Malaspina expedition.

height at Chili of the lower limit of snow, in the 33° of south latitude. The limit does not lower in summer to 2000 toises *. I think we may conclude, according to the analogy of the *snowy mountains* of Mexico and southern Europe, and considering the difference of the *estivale* temperatures of the two hemispheres, that the real *Nevadas* at Chili, in the parallel of Valdivia (lat. 40°), cannot be below 1300 toises; in that of Valparaiso (lat. 33°), not lower than 2000 toises, and in that of Copiapo (lat. 27°) not below 2200 toises of absolute height. They are the limit numbers, the *minimum* of elevation, which the ridge of the Andes of Chili must attain by different degrees of latitude, in order that their summits, more or less grouped, pass not the line of perpetual snows. The numeric results which I have just marked, and which are founded on the laws of the distribution of heat, have still the same importance as they had at the period already distant of my travels in America; *for there does not exist in the immense extent of the Andes, from 8° of south latitude to the strait of Magellan, one Nevada of which the height above the level of the Ocean has been determined, either by*

* On the *southern declivity* of the Himalaya, the snows begin 3° nearer the equator, at 1970 toises.

a simple geometric measure, or by the combined means of barometric, and geometric measures *.

The Andes, between 33° and 18° of south latitude, between the parallels of Valparaiso and Arica, present towards the east three remarkable counter-forts, the Sierra de Cordova, de Salta, and the Nevados de Cochabamba. Travellers partly cross, and partly go along the side of the *Sierra de Cordova* (between 33° and 31° of latitude), in their way from Buenos Ayres to Mendoza; it may be said to be the most southern promontory which advances in the Pampas, towards the meridian of 65°; it gives birth to the great river known by the name of Desaguadero of Mendoza, and extends from San Juan de la Frontera and San Juan de la Punta to the town of Cordova. The second counter-fort, the Sierra de Salta and the Jujui, of which the greatest breadth is 25° of latitude, widens progressively from the valley of Catamarca and San Miguel del Tucuman, towards

* The simultaneous employment of both these means is necessary wherever a base cannot be measured at the level of the sea, or a plan taken from the table-land on which the base has been measured as far as the coast. The want of portable barometers, and ignorance of the use of instruments of reflexion, and artificial horizons, retard the progress of physical geography in the high chains of mountains; and has been especially prejudicial to the hypsometry of the Andes, and the Rocky Mountains.

the Rio Vermejo (longitude 64°). Finally, the third, and most majestic counter-fort, the *Sierra Nevada de Cochabamba and Santa Cruz* (from 22° to 17½° of latitude), is linked with the knot of the mountains of Porco. It forms the point of partition (*divortia aquarum*), between the basin of the Amazon and that of the Rio de la Plata. The Cachimayo and the Pilcomayo, which rise between Potosi, Talavera de la Puna, and La Plata or Chuquisaca, run towards the south-east, while the Parapiti and the Guapey (Guapaiz, or Rio de Mizque), pour their waters into the Mamori, towards the north-east. The *ridge of partition* being placed near Chayanta, south of Mizque, Tomina, and Pomabamba, nearly on the southern declivity of the Sierra de Cochabamba in the 19° and 20° of latitude, the Rio Guapey is forced to flow around the whole group, in order to reach the plains of the Amazon, like the Poprad in Europe, a tributary stream of the Vistula, to attain the southern part of the Carpathes of Tatra in the plains of Poland. I have already observed above, that where the mountains cease (west * of the meridian of

* I suppose, with Captain Basil Hall, that the port of Valparaiso is 71° 31′ west of Greenwich, and I place Cordova 8° 40′, and Santa Cruz de la Sierra 7° 4′ east of Valparaiso. The longitudes indicated in the text, and constantly referring to the meridian of the Observatory of Paris, are

66½°), the ridge of partition of Cochabamba goes up towards the north-east, to 16° of latitude, forming by the intersection of two planes slightly inclined, one *wall* only amidst the savannahs, and separating the waters of the Guaporé, a tributary stream of the Madeira, from those of the Aguapehy and Jauru, tributary streams of the Rio Paraguay. This vast country between Santa Cruz de la Sierra, Villabella, and Matogrosso, is one of the most unknown of South America. The two counter-forts of Cordova and Salta present only a mountainous territory * of small elevation, and which is linked to the foot of the Andes of Chili. The counter-fort of Cochabamba, on the contrary, attains the limit of perpetual snows (2300 toises), and forms in some sort a lateral branch of the Cordilleras, diverging even from their tops between La Paz and Oruro. The mountains composing this branch (Cordillera de Chiriguanaes, de los Sauces and Yuracarées), stretch regularly from west to east; their eastern de-

not taken from published maps; they are founded on combinations of astronomical geography of which the elements will be found in the Analysis of my Atlas of South America.

* I can scarcely believe that even the town of Jujuy is 650 toises above the level of the Ocean, as Mr. Redhead pretends in his book *Sobre la dilatacion del aire atmosferico.* (Buenos Ayres, 1819,) p. 10.

clivity * is very rapid, and their loftiest summits are placed not at the centre, but in the northern part of the group.

The principal Cordillera of Chili and Upper Peru, after having thrown towards the east the three counter-forts of Cordova, Salta, and Cochabamba, or Santa Cruz, is, for the first time, ramified very distinctly into two branches, in the *knot of Porco, and Potosi*, between 19° and 20° of latitude. These two branches comprehend the table-land extending from Carangas to Lampa (lat. 19½°—15°) and which contains the small alpine lake of Paria, the Desaguadero, and the great Laguna of Titicaca or Chucuito, of which the western part bears the name of Vinamarca. To give a just idea of the colossal dimensions of the Andes, I shall here observe that the surface of the lake of Titicaca only (448 square marine leagues) exceeds twenty times that of the lake of Geneva, and twice the mean extent of a department of France. It is

* I owe a more perfect knowledge of the Sierra de Cochabamba, to the manuscripts of my countryman the celebrated botanist, Taddeus Haenke, which a monk of the congregation of the Escurial, father Cisneros, kindly communicated to me at Lima. Mr. Haenke, after having followed the expedition of Alexander Malaspina, settled at Cochabamba, in 1798, where he received great proofs of the friendship of the intendant, Don Francisco de Viedma. A part of the immense herbal of this botanist is now at Prague.

on the banks of this lake, near Tiahuanacu, and in the high plains of Collao, that ruins are found which attest a state of civilization * anterior to that which the Peruvians attribute to the reign of the Inca Manco Capac. The eastern Cordillera, that of Le Paz, Palca, Ancuma, and Pelechuco, join, north-west of Apolobamba, the western Cordillera, which is the most extensive of the whole chain of the Andes, between the parallels 14° and 15°. The *imperial town* of Cuzco is placed near the eastern extremity of this knot, which comprehends, in an area of 3000 square leagues, the mountains of Vilcanota, Carabaya, Abancai, Huando, Parinacochas, and Andahuaylas. Although here, as in general, in every considerable widening of the Cordillera, the grouped summits do not follow the principal axis in constant and parallel directions, a phenomenon was however observed in the general disposition of the chain of the Andes, from lat. 18° well worthy the attention of geologists. The whole mass of the Cordilleras of Chili and Upper Peru, from the strait of Magellan to the parallel of the port of Arica (18° 28′ 35″), is directed from south to north, in the manner of a meridian at most 5° N. E.; but from the parallel of Arica, the coast, and the two Cordilleras east and west of the

* *Garcilasso, Comentarios Reales*, T. I. p. 21.

Alpine lake of Titicaca change their direction abruptly, and incline towards the north-west. The Cordilleras of Ancuma and Moquehua, and the longitudinal valley, or rather the basin of Titicaca, which they inclose, are directed N. 42° W. Further on, the two branches again unite in the *knot of the mountains of Cuzco*, and thence their direction is N. 80° W. This knot, of which the table-land inclines to the north-east, presents a real curve, nearly directed from east to west, so that the part of the Andes north of Castrovireyna is thrown back more than 242,000 toises towards the west. So singular a geological phenomenon reminds us of the *variation d'allure* of the veins, and especially of the two parts of the chain of the Pyrenees, parallel to each other, and linked by an almost rectangular elbow, 16,000 toises long, near the source of the Garonne *; but in the Andes, the axes of the chain, south and north of the curve, do not preserve a parallelism. On the north of Castrovireyna and Andahuaylas (lat. 14°), the direction is N. 22° W., while south of 15°, it is N. 42° W. The inflexions of the coast follow these changes; the shore separated from the Cordillera by a plain 15 leagues broad, stretches like the Cordillera at Arica, between 27½° and

* Between the mountain of Tentenade and the Port d'Espot (*Charpentier*, p. 10).

18½° of latitude, N. 5° E.; from Arica to Pisco, between 18½° and 14° latitude, at first N. 42° W., afterwards N. 65° W.; and from Pisco to Truxillo, between 14° and 8° of latitude, N. 27° W. The parallelism between the coast and the Cordillera of the Andes is a phenomenon so much more worthy of attention, that it is repeated in several parts of the globe where the mountains do not in the same manner form the shore. To this consideration is joined another which relates to the general outline of continents. I fix on the geographical position of the point (14° 28′ south latitude) where, on the parallel of Arica, the inflexion of the coast, and the *variation d'allure* of the Andes of Upper Peru, begin. The resemblance of configuration which the triangular masses of South America and Africa display, is manifest in many details of their outline. The gulphs of Arica, and of Ilo correspond to the gulph of Guinea. The inflexion of the western coast of Africa begins 3° north of the equator; and if we consider the Archipelago of India geologically, as the remains of a destroyed continent, as the link between eastern Asia and New Holland, we see the gulph of Guinea, that which forms Java, Bali, and Sumbava, with the Land de Witt, and the Peruvian gulph of Arica, following from north-west to south-south-east (lat. 3° N. lat. 10° S., lat. 14¼° S.), almost in the same di-

rection as the extremities of the three continents of Africa, Australasia, and America *.

After the great *knot of mountains* of *Cuzco* and *Parinacochas*, in 14° south latitude, the Andes present a *second bifurcation*, on the east and west of the Rio Jauja, which throws itself into the Mantaro, a tributary stream of the Apurimac †. The eastern chain stretches on the east of Huanta, the convent of Ocopa and Tarma, the western chain, on the west of Castrovireyna, Huancavelica, Huarocheri, and Yauli. The basin, or rather the lofty table-land which is inclosed by these chains, is nearly half the length of the basin of Chucuito or Titicaca. Two mountains covered with eternal snow, seen from the town of Lima, and which the inhabitants name *Toldo de la Nieve*, belong to the western chain, that of Huarocheri.

On the north-west of the vallies of Salcabamba, in the parallel of the ports of Huaura and Guarmey, between 11° and 10° latitude, the two chains unite in the knot of the Huanuco and the Pasco, celebrated for the mines of Yauricocha or Santa Rosa. There rise two peaks of colossal height, the Nevados of Sasa-

* See above, p. 393.

† See le *Plan del curso de los Rios Huallaga y Ucayali por don Padre Sobreviela*, 1791. The Apurimac forms, conjointly with the Beni, the Rio Paro, which takes the name of Ucayali, after its confluence with the Rio Pachitea.

guanca and of la Viuda. The table-land of this knot of mountains appears in the Pampas de Bombon *, to be more than 1800 toises above the level of the Ocean. From this point, on the north of the parallel of Huanuco, (lat. 11°) the Andes are divided into three chains, of which the first, and most eastern, rises between Pozuzu and Muna, between the Rio Huallaga, and the Rio Pachitea, a tributary of the Ucayali; the second, or central, between the Huallaga, and the Upper Maragnon; the third, or western, between the Upper Maragnon and the coast of Truxillo and Payta †. The eastern chain is a small lateral branch which lowers into a range of hills; directed first towards the N.N.E., bordering the Pampas del Sacramento; afterwards towards the W.N.W., where it is broken by the Rio Huallaga, in the Pongo, above the confluence of Chipurana, the eastern chain loses itself in 6¼° of latitude, on the north-west of Lamas. A transversal ridge seems to join it with the central chain, south of Paramo ‡, de Piscoguanuna (or Piscuaguna), west of Chachapoyas. The intermediary or central chain stretches from the knot of Pasco and Huanuco, towards the N.N.W. between Xican

* Political Essay, Vol. iii, p. 341.

† See above, Vol. v, p. 30.

‡ See above, Vol. ii, p. 253—Vol. v, p. 742.

and Chicoplaya, Huacurachuco and the sources of the Rio Monzan, between Pataz and Pajatan, Caxamarquilla and Moyobamba. It widens greatly in the parallel of Chachapoyas, and forms a mountainous territory, traversed by deep vallies, excessively hot. The central chain, in 6° latitude, on the north of Paramo de Piscoguanuna, throws two branches towards La Vellaca and San Borja. We shall soon see that this latter branch forms, below the Rio Neva, a tributary stream of the Amazon, the rocks that border the famous Pongo de Manseriche. In this zone, where northern Peru draws near the confines of New Grenada in 10° and 5° of latitude, no summit of the eastern and central chains rises as high as the region of perpetual snows; the only snowy tops are in the western chain. The central chain, that of the Paramos de Callacalla, and Piscoguanuna, scarcely reaches 1800 toises, and lowers gently to 800 toises; so that the mountainous and tempered land which extends on the north of Chachapoyas towards Pomacocha, La Vellaca, and the source of the Rio Nieva, is still rich in fine trees of quinquina. After having passed the Rio Huallaga and the Pachitea, which with the Beni forms the Ucayali, we find in advancing towards the east, only ranges of hills. The western chain of the Andes, which is the most elevated and the nearest to the coast, stretches almost in a parallel with

the shore N. 22° W.; between Caxatambo and Huary, Conchucos and Guamachuco, by Caxamarca, the Páramo de Yanaguanga and Montan, towards the Rio de Guancabamba. It presents (between 9° and 7½°) the three *Nevados* de Pelagatos, Moyopata, and Huaylillas. This last snowy summit, situated near Guamachuco, (in 7°55′ latitude) merits the more particularly to fix attention, since from thence on the north, as far as Chimborazo, on a length of 140 leagues, there exists not one mountain that enters the region of perpetual snows. This depression or absence of snows, extends in this interval, over all the lateral chains, while, on the south of the Nevado de Huaylillas, we constantly observe that when one chain is very low, the summits of the other surpass the height of 2460 toises. In order to fix attention the more on the branch of the Andes which extends on the west of the Amazon, that of Conchucos and Caxamarca, I shall here repeat that it was on the south of Micúipampa (lat. 7° 1′) that I found the magnetic equator.

The Amazon, or as it is customary to say in those regions, the Upper Maragnon, passes through the western part of the longitudinal valley which lies between the Cordilleras of Chachapayas, and Caxamarca. Comprehending in one point of view, this valley, and that of Rio Jauja, bounded by the Cordilleras of

Tarma and Huarocheri, we are inclined to consider them as one immense basin 180 leagues long; and crossed at the first third of its length, by a dyke, or ridge 18,000 toises broad. In fact, the two Alpine lakes of Lauricocha and Chinchaycocha, which give birth to the river of the Amazons and the Rio de Jauja, are placed south and north of this rocky dyke, formed by a prolongation of the knot of Huanuco and Pasco. The Amazon, in issuing from the longitudinal valley, that bounds the chains of Caxamarca and Chachacocha, breaks, as we have already said in another place *, the latter of those chains, which merits the name of central without being the most lofty; the point where the great river penetrates into the mountains is very remarkable. Entering the Amazon by the Rio Chamaya or Guancabamba, I found opposite the confluence, the picturesque mountain of Patachuana; but the rocks on both banks of the Amazon begin only between Tambillo and Tomependa (lat. 5° 31', long. 80° 56'). From thence to Pongo de Rentema, a long succession of rocks follow, of which the last is the Pongo de Tayouchouc, between the strait of Manseriche and the village of San Borja. The course of the Amazon, at first directed north, and then east, changes near Pu-

* Vol. v, p. 41.

yaya, three leagues north-east of Tomependa. In the whole of this distance, between Tambillo and San Borja, the waters force a way, more or less narrow, across the sand-stone of the Cordillera of Chachapoyas. The mountains are lofty near the Embarcadero, at the confluence of the Imasa, where trunks of Cinchona, which might be easily transplanted to Cayenne, or the Canaries, approach the Amazon. The rocks in the famous strait of Manseriche, are scarcely 40 toises high; and further eastward, the last hills rise near Xeberos, towards the mouth of the Rio Huallaga.

In order not to interrupt the description of the Cordilleras, between the 15° and 5½° of latitude, between the knots of the mountains of Cuzco and Loxa, I have hitherto passed over in silence the extraordinary widening of the Andes near the Apolobamba. The sources of the Rio Beni being found in this *counter-fort*, which stretches towards the north, beyond the confluence of that river with the Apurimac, I shall designate the whole group by the name of the *counter-fort of Beni*. The following is the most certain information I have obtained respecting those countries, from persons who had long inhabited Apolobamba, the *Real* of the mines of Pasco, and the convent of Ocopa. Along the whole eastern chain of Titicaca, from La Paz to the knot of Huanuco (lat. 17½° to 10½°) a very wide

mountainous land lies towards the east, at the back of the declivity of the Andes. It is not a widening of the eastern chain itself, but rather of the *counter-forts* of small height that follow the foot of the Andes like a penumbra, filling the whole space between the Beni and the Pachitca. A chain of hills bounds the eastern bank of the Beni to 8° of latitude; for, according to the very exact information I received from father Nacisso Gilbar, the rivers Coanache and Magua, tributaries of the Ucayali (flowing in the 6° and 7° latitude), come from a mountainous land between the Ucayali and the Javari. The existence of this land in so eastern a longitude (probably long. 74°), is so much more remarkable, as we find at four degrees of latitude further north, neither a rock nor a hill on the east of Xeberos, or the mouth of the Huallaga (long. 77° 56′).

We have just seen that the counter-fort of Beni, a sort of lateral branch, loses itself towards 8° of latitude; the chain between the Ucayali and the Huallaga terminates at the parallel of 7° in joining, on the west of Lamas, the chain of Chachapayas, stretching between the Huallaga and the Amazon. Finally, the latter chain, which we have also designated by the name of central, after having formed the rapids and cataracts of the Amazon, between Tomependa and San Borja, turns towards the north-north-west,

and joins the western chain, that of Caxamarca, or the Nevados of Pelagatos and Huaylillas, and forms the *great knot of the mountains of Loxa*. The mean height of this knot is only 1000 to 1200 toises; its temperate climate renders it peculiarly fitted for the vegetation of the trees of quinquina, the finest kinds of which grow in the celebrated forests of Caxahuma and Uritusinga, between the Rio Zamora and the Cachiyacu, and between Tavacona and Guancabamba. For ages, before the quinquina of Popayan and Santa Fe de Bogota (nor. lat. 2½° to 5°), of Huacarachuco, Huamalies, and Huanuco (south lat. 9° to 11°), was known, the knot of the mountains of Loxa was regarded as the sole region from whence the febrifuge bark of Cinchona could be obtained. This knot occupies the vast territory between Guancabamba, Avayaca, Oña, and the ruined towns of Zamora and Loyola, between 5½° and 3¼° of latitude. Some of the summits (the *Paramos* of Alpachaca, Saraguru, Savanilla, Gueringa, Chulucanas, Guamani, and Yamoca, which I measured), rise from 1580 to 1720 toises, but are not as a groupe covered with snows, which in this latitude falls only above 1860 to 1900 toises of absolute height. In descending towards the east, to the Rio Santiago and the Rio of Chamaya, two tributary streams of the Amazon, the mountains lower rapidly; between San

Felipe, Matara, and Jaen de Bracamoros, they are not more than 500 or 300 toises.

As we advance from the mountains of mica-slate of Loxa towards the north, between the *Paramos* of Alpachaca and Sarar (in latitude 3° 15′), the knot of mountains is ramified into two branches that comprehend the longitudinal valley of Cuenca. This separation lasts on a length of only 12 leagues; for in the 2° 27′ of latitude, the two Cordilleras join anew in the *knot of Assuay*, a trachytic groupe, of which the table-land, near Cadlud, 2428 toises high, enters nearly into the region of perpetual snow.

At the knot of the mountains of Assuay, which affords a very frequented *passage of the Andes*, between Cuenca and Quito, succeeds (lat. 2½° to 0° 40′ south), another division of the Cordilleras become celebrated by the labors of Bouguer and La Condamine, who have placed their signals sometimes on one, sometimes on the other of the two chains. The eastern is that of Chimborazo (3350 toises) and of Cargual-razo; the western, the chain of the volcano Sangay, the Collanes, and of Llanganate. The latter is broken by the Rio Pastaza. The bottom of the longitudinal basin that bounds those two chains, from Alausi to Llactacunga, is a little higher than the bottom of the basin of Cuenca. North of Llactacanga, 0° 40′ latitude,

between the tops of Yliniza (2717 t.) and Cotopaxi (2950 t.), of which the former belongs to the chain of Chimborazo, and the latter to that of Sangay, is placed the *knot of Chisinche;* a kind of narrow dyke that shuts in the basin, and divides the waters between the Atlantic Ocean, and the South Sea. The *Alto de Chisinche* is only elevated 80 toises above the surrounding table-lands. The waters of the northern declivity form the Rio de San Pedro, which, joining the Rio Pita, throws itself into the Gualabamba, or Rio de las Esmeraldas. The waters of the southern declivity, designated more particularly by the name of Cerro de Tiopullo, run to the Rio of S. Felipe and Pastaza, a tributary stream of the Amazon.

The *bipartition* of the Cordilleras re-commences and continues from 0° 40′ of south to 0° 20′ of north latitude; that is, as far as the volcano of Imbabura, near the villa of Ibarra. The eastern Cordillera displays the snowy summits of Antisana (2992 toises), of Guamani, Cayambe (3070 toises), and Imbabura; the western Cordillera, those of Corazon, Ataçazo, Pichincha (2491 toises), and Cotocache (2570 toises). Between these two chains, which may be regarded as the classical soil of the astronomy of the 18th century, is a valley, part of which is again divided longitudinally by the hills of Ichimbio and Poignasi. The table-lands

of Puembo and Chillo lie on the east of those hills; and those of Quito, Iñaquito, and Turubamba on the west. The equator crosses the summit of Nevado de Cayambe *, and the valley of Quito in the village of San Antonio de Lulumbamba. When we consider the small mass of the knot of Assuay, and above all, of that of Chisinche, we are inclined to regard the three basins of Cuenca, Hambato, and Quito, as one long valley (from the Paramo de Sarar, to the Villa de Ibarra) of 73 marine leagues, 4 or 5 leagues broad, having a general direction N. 8° E. and divided by two transversal dykes, one between Alausi and Cuenca (2° 27′ south latitude), and the other between Machache and Tambillo (0° 40′). No where in the Cordillera of the Andes are more colossal mountains heaped together, than on the east and west of this vast basin of the province of Quito, one degree and a half south, and a quarter of a degree north of the equator. This basin, the centre of the most ancient native civilization, after that of the basin of Titicaca, touches towards the south, the knot of the mountains of Loxa, and towards the north, the table-land of the province of Los Pastos.

* The heights of Chimborazo, Rucupichincha, Cayambe, and Antisana, which are different from those stated by La Condamine, in the inscription at the convent of Jesuits at Quito, are the result of my own geodesic measurements.

In this province, a little beyond the Villa of Ibarra, between the snowy summits of Cotocache and Imbabura, the two Cordilleras of Quito join, and form one mass, extending to Meneses and Voisaco, from 0° 21′ nor. lat. to 1° 13′. I call this mass, on which the volcanoes of Cumbal and Chiles rise, the *knot of the mountains of Los Pastos*, on account of the name of the province that forms the center. The volcano of Pasto, of which the last eruption took place in the year 1727, is on the south of Yenoi, near the northern limit of this groupe, of which the inhabited table-lands are more than 1600 toises above the level of the Ocean. It is the Thibet of the equinoxial regions of the New World.

On the north of the town of Pasto (north latitude 1° 13′; long. 79° 41′), the Andes again divide into two branches, and surround the table-land of Mamendoy and Alinaguer. The eastern Cordillera contains the Sienega of Sebondoy (an alpine lake that gives birth to the Putumayo), the sources of the Jupura or Caqueta, and the Paramos of Aponte and Iscanse. The western Cordillera, that of Mamacondy, called in the country *Cordillera de la Costa*, on account of its proximity to the shore of the South-Sea, is broken by the great Rio de Patias, which receives the Guativa, the Guachicon, and the Quilquase. The table-land or intermediary basin has great inequalities; it is partly filled

by the Paramos of Pitatumba and Paraguay, and the separation of the two chains appeared to me indistinct as far as the parallel of Almaguer (lat. 1° 54′; long. 79° 15′). The general direction of the Andes, from the extremity of the basin of the province of Quito to the vicinity of Popayan, changes from N. 8° E. to N. 36° E.; and follows the direction of the coast of Esmeraldas and Barbacoas.

On the parallel of Almaguer, or rather a little north-east * of that town, the geological constitution of the land displays very remarkable changes. The Cordillera, which we have just marked by the name of the eastern, that of the lake of Sebondoy, widens considerably between Pansitara and Ceja. The knot of the *Páramo de las Papas and of Socoboni*, gives birth to the great rivers of Cauca and Magdalena, and is divided into two chains, latitude 2° 5′ on the east and west of la Plata Vieja and Timana. These two chains remain nearly parallel as far as 5° of latitude, and bound the longitudinal valley through which winds the Rio Magdalena. We shall give the name of the *eastern Cordillera of New Grenada*, to that which stretches towards Santa Fe de Bogotá and the Sierra Nevada de Merida, east of Magdalena; that of *central Cor-*

* See my map of the Rio Magdalena, pl. 24 of the *Atlas geographique et physique.*

dillera of New Grenada, to that which lies between the Magdalena and the Cauca, towards Mariquita; and that of the *western Cordillera of New Grenada*, to the chain which continues the *Cordillera de la Costa* from the basin of Almaguer, and separates the bed of the Rio Cauca from the platiniferous territory of Choco. In order to be clearer, we may also name the first chain, that of Suma Paz, after the colossal groupe of mountains on the south of Santa Fe de Bogota, which throws the waters of its eastern declivity into the Rio Meta. The second chain may bear the name of the chain of *Guanacas* or Quindiu, on account of the two celebrated passages of the Andes, in the way from Santa Fe de Bogota to Popayan. The third chain may be called that of *Choco*, or of the *shore*. Some leagues on the south of Popayan (nor. lat. 2° 21'), west of Paramo de Palitara and the volcano of Puracé, a ridge of micaslate runs from the *knot of the mountains* * *of Sacoboni*, towards the north-west, and divides the waters between the South Sea and the Caribbean Sea; they flow from the northern declivity into the Rio Cauca, and from the southern declivity, into the Rio de Patias.

The *tripartition* of the Andes, which we have

* See my *Essai géogn. sur le gisement des roches*, p. 130 and 131.

just stated, (north lat. 1½° — 2½°) reminds the geognost of that which takes place at the source of the Amazon in the *knot of the mountains of Huanuco and Pasco* (south lat., 11°); but the most western of the three chains that bound the basins of the Amazon and the Huallaga, is the loftiest; while that of Choco, or the shore, is the least elevated of the three chains of New Grenada. It is ignorance of this tripartition of the Andes in that part of South America near the Rio Atrato and the isthmus of Panamá, which has led to so many erroneous judgments on the possibility of a canal of junction between the two seas *.

The eastern chain of the Andes of New Grenada, (I employ a systematic denomination, for the name of the Andes is unknown in the countries situated north of the equator,) the eastern chain preserves its parallelism during some time with the two other chains, those of Quindiu and Choco; but beyond Tunja (lat. 5½°), it inclines more towards the north-east, passing somewhat abruptly from the direction N. 25° E. to that of N. 45° E. It is like a vein that changes its direction, and rejoins the coast after an extraordinary enlargement which it undergoes by the grouping of the snowy mountains of Merida. The tripartition of the Cor-

* See above, Vol. v, p. 248.

dilleras, and above all, the spreading of their branches, have a powerful influence on the prosperity of the nations of New Grenada. The diversity of the superposed table-lands and climates varies the agricultural productions as well as the character of the inhabitants; it gives activity to the exchange of products, and renews on a vast surface, on the north of the equator, the picture of the sultry vallies, and the cold and temperate plains of Peru. It is also worthy of remark that, by the separation of one of the branches of the Cordilleras of Cundinamarca, and the deviation of the chain of Bogota towards the north-east, the colossal groupe of the mountains of Merida is enclosed in the territory of the *ancient Capitania-general* of Venezuela, and that the continuity of the same mountainous land from Pamplona to Barquesimeto and Nirgua, has, it may be said, facilitated the political union of the Columbian territory. As long as the central chain (that of Quindiu) displays its snowy summits, no peak of the eastern chain (that of La Suma Paz) rises, in the same parallels, to the limit of perpetual snows. Between 2° and 5½° of latitude, neither the Paramos, situated on the east of Gigante and Neiva, nor the tops of la Suma Paz, Chingasa, Guachaneque, and Zoraca, surpass the height of 1900 to 2000 toises; while on the north of the parallel of Paramo d'Erve

* (lat. 5° 5′), the last of the Nevados of the central Cordillera, we discover in the eastern chain the snowy summits of Chita (lat. 5° 50′), and of Mucuchies (lat. 8° 12′). It thence results, that from 5° latitude, the only mountains covered with snow during the whole year, are the Cordilleras *of the east*; and although the Sierra Nevada of Santa Marta is not, properly speaking, a continuation of the Nevados of Chita and Mucuchies (west of Patute, and east of Merida), it is at least very near their meridian.

Arrived at the northern extremity of the Cordilleras, comprehended between Cape Horn and the isthmus of Panama, we shall confine ourselves to the indication of the loftiest summits of the three chains † which separate in the *knot of the mountains of Socoboni, and the ridge of Roble* (lat. 1° 50′ — 2° 20′). I begin with the most eastern chain, that of Timana and Suma Paz, which divides the tributary streams of the Magdalena and the Meta; it stretches by the Paramos de Chingasu, Guachaneque, Zoraca, Toquillo (near Labranza Grande), Chita, Almorsadero ‡, Laura, Cacota,

* The snows called at Santa Fe, *Mesa de Herveo*.

† *See* above, 248.

‡ This Paramo is situated between the bridge of Chitaga and the village of Tequia. The Rio Chitaga throws itself into the Sarare, and the Rio Tequia, into the Rio Sogamozo.

Zumbador, and Porqueras, towards the Sierra Nevada de Merida. These Paramos indicate ten partial risings of the back of the Cordilleras. The declivity of the eastern chain is extremely rapid on the eastern side, where it bounds the basin of the Meta and the Oroonoko; it is widened on the west by the counterforts, on which are situated the towns of Santa Fe de Bogota, Tunja, Sogamoso, and Leiva. They are like table-lands fixed to the western declivity, and which are from 1300 to 1400 toises high; that of Bogota, (the bottom of an ancient lake), contains bones of Mastodontes, in the Campo de Gigantes, near Suacha.

The intermediary, or central chain, runs on the east of Popayan, by the high plains of Mabasa, the Paramos of Guanacas, Huila, Savelillo, Iraca, Baraguan, Tolima *, Ruiz, and Herveo, towards the province of Antioquia. In the 5° 15′ of latitude, this chain, the only one that displays recent traces of volcanic fire, in the

* The Paramos of the Almosadero and Toquillo are the most lofty summits which, on the road from Merida to Santa Fe de Bogota, do not enter the region of perpetual snows. MM. Rivero and Boussingault found that the Paramo of Almorsadero is passed at the elevation of 2010 toises, and the Paramo of Cacota at 1700 toises.

The passage of the Montana de Quindiu, on the road from Ibague to Carthago, is between the Nevados of Tolima, and Baraguan.

summits of Sotara and Purace, widens considerably towards the west, and joins the western chain, which we have called the chain of Choco, because the planitiferous land of that province lies on the slope opposite the Pacific Ocean. By the union of the two chains, the basin of the province of Popayan is shut on the north of Cartago Viejo, and the river of Cauca, in issuing from the plain of Buga, is forced, from the Salto de San Antonio, to la Boca del Espiritu Santo, to open its way across the mountains, during a course of from 40 to 50 leagues. The difference of the level is very remarkable, in the bottom of the two parallel basins of Cauca and Magdalena. The former, between Cali and Cantago, is from 500 to 404 toises; the latter, from Neiva to Ambalema, is from 265 to 150 toises high. It might be said, according to different geological hypotheses, either that the secondary formations were not accumulated to the same thickness between the eastern and central, as between the central and western chains; or, that the deposits have been made on the base of primitive rocks, unequally heaped up on the east and west of the Andes of Quindiu. The mean difference of this thickness of formation, or of these heights, is 300 toises. The rocky ridge of the Angostura of Carare, branches from the south-east, from the counter-fort of Muzo, through which winds the Rio Negro.

By this counter-fort, and by those that come from the west, the eastern and central chains approach between Nares, Honda, and Mendales. In fact, the bed of the Rio Magdalena is narrowed in 5° and 5° 18′, by the mountains of Sergento on the east, and by the counterforts that are linked with the granitic mountains of Mariquito and S. Ana, on the west. This narrowing of the bed of the river is in the same parallel with that of the Cauca, near the Salto de San Antonio; but, in the knot of the mountains of Antioquia, the central and western chains join each other; while between Honda and Mendales, the tops of the central and eastern remain so far removed, that it is only the counter-forts of each system that draw near and are confounded together. It is also worthy of remark, that the central Cordillera of New Grenada displays the loftiest summit of the Andes in the northern hemisphere. The peak of Tolima * (lat. 4° 46′), of which the name is almost unknown in Europe, and which I measured in 1801, rises at least 2865 toises high. It consequently surpasses the Imbabura, and the Cotocache in the province of Quito, the Chiles of the table-lands of los Pastos, the two volcanoes of Popayan,

* The second rank of height, in the northern hemisphere, appears to be occupied by the *Nevado de Huila* (lat. 2° 55′), between Natagá and Quilichao. M. Caldas' estimates it 2800 toises. (See *Semanario de Bogota*, Tom. i. p. 6.)

and even the Nevados of Mexico and the Mount Saint Elie of Russian America. The peak of Tolima, which in form resembles Cotopaxi, yields perhaps in height only to the ridge of the Sierra Nevada de Santa Marta, which may be considered as an insulated system of mountains.

The eastern chain, also called *chain of Choco and the coast* (of the South Sea), separates the provinces of Popayan and Antioquia from those of Barbacoas, Raposo, and Choco. Little elevated in general, if compared to the height of the central and eastern chains, it however presents great obstacles to the communications between the valley of Cauca and the shore *. On its western slope lies the famous *auriferous* and *platiniferous* land †, which has during

* The frightful roads that cross the western chain, are those of Chisquio (east of the Rio Micay), Anchicaya, las Juntas, Saint Augustin, opposite Cartago, Chami, and Urrao. (*Seman.*, Tom. i, p. 32.

† The Choco Barbacoas and Brazil are the only countries of the earth where the existence of grains of platina and of palladium has been hitherto fully ascertained. The small town of Barbacoas is situated on the left bank of the Rio Telembi (tributary of Patias or the Rio del Castigo), a little above the confluence of Telembi and the Guagui or Guaxi, nearly in 1° 48′ of latitude. The ancient *Provincia*, or rather the *Partido del Rasposo*, comprehends the insalubrious land extending from the Rio Dagua, or San Buenaventura to the Rio Iscuande, the southern limit of Choco.

ages yielded more than 13,000 marks of gold annually to commerce. This alluvial zone is from 10 to 12 leagues broad: it attains its maximum of riches between the parallels of 2° and 6° of latitude, is sensibly impoverished towards the north and south, and almost entirely disappears between 1½° of north latitude and the equator. The auriferous soil fills the basin of Cauca, as well as the ravines and plains on the west of the Cordillera of Choco; it rises sometimes nearly 600 toises above the level of the sea, and descends at least 40 toises *. Platina (and this geognostic fact is worthy of attention), has hitherto been found *only on the* west of the Cordillera of Choco, and not on the east, notwithstanding the analogy of the fragments of rocks, of greenstone, phonolite, trachyte, and ferruginous quartz, of which the soil of the two descents is composed. From the ridge of Los Robles, which separates the table-land of Almaguer from the basin of Cauca, the western chain forms, first, in the Cerros of Carpinteria, east of the Rio San Juan de Micay, the continuation of the Cordillera of Sindagua, broken by the Rio Patias; then, lowers towards the north, between Cali and Las Juntas de Dagua, to from

* M. Caldas assigns to the *upper limit of the zone of gold washings*, only the height of 350 toises. (*Seman.*, Tom. i, p. 18); but I found the *lavaderos* of Quilichao, on the north of Popayan, 565 toises high. (*Astron. Obs.*, Vol. i, p. 303.)

800 to 900 toises of height, and sends considerable counter-forts (in $4\frac{1}{4}° - 5°$ of latitude) towards the source of the Calima, the Tamana, and the Andagueda. The two former of these auriferous rivers are tributary streams of the Rio Rio San Juan del Choco; the second empties its waters into the Atrato. This widening of the western chain forms the mountainous part of Choco: here, between the Tado and Zitara, called also Francisco de Quibdo, lies the isthmus of Raspadura, become celebrated since a monk traced on it a navigable line between the two oceans *. The culminant point of this system of mountains appears to be the Peak of Torra, situated on the south-east of Novita †.

The northern extremity of this widening of the Cordillera of Choco, which I have just described, corresponds with the junction of the same Cordillera towards the east, with the central chain, that of Quindiu. The mountains of Antioquia, on which we have the excellent observations of Mr. Restrepo ‡, may be called a *knot of*

* See above, Vol. vi, p. 260.

† I am surprized that M. Pombo has compared the *Torra del Choco*, which does not enter into the region of shows, not even perhaps into that of the Paramos (see above, Vol. v, p. 742), to the colossal mountains of Mexico. (*Noticias varias sobre las Quinas*, 1814, p. 67.)

‡ *Semanario de Bogota*, Tom. ii, p. 41—96. This memoir contains at the same time, the results of astronomical observations, the measures made with the barometer, and statistic statements on the productions and trade of this in-

mountains, because on the northern limit of the plains of Buga, or the basin of Cauca, they join the central and western chains. We have seen above, that the ridge of the eastern Cordillera remains separated by 35 leagues of distance from the knot, so that the narrowing of the bed of the Rio Magdalena, between Honda and Ambalema, results only from the approximation of the counter-forts of Mariquita and Guaduas. There is not therefore, properly speaking, a groupe of mountains, between 5° and 5¼° of latitude, uniting at the same time the three chains. In the groupe of the province of Antioquia, which forms the junction of the central and western Cordilleras, we may distinguish two great masses, one, between the Magdalena and the Cauca, the other, between the Cauca and the Atrato. The first of these masses is linked most immediately to the snowy summits of Herveo; it gives birth on the east, to Rio de la Miel, and the Nare; and towards the north, to Porce and Nechi; its mean height is only from 1200 to 1350 toises. The culminant point appears to be placed near Santa Rosa, south-west of the celebrated valley of Bears. *(Valle de Osos.)* The towns of Rio Negro and

teresting province, of which I attempted to trace, in 1816, the first geographical map, from the labors of M. Manuel Jose de Restrepo. (See 24th Pl. of my *Atlas*.)

Marinilla are built on table-lands 1060 toises high. The western mass of the knot of the mountains of Antioquia, between the Cauca and the Atrato, gives rise, on its western descent, to the Rio San Juan, Bevara, and Murri. It attains its greatest height (and that of the whole province of Antioquia) in the *Alto del Viento*; north of Urrao, known to the first *Conquistadores* by the name of the Cordilleras of Abide *, or Dabeida. This height (lat. 7° 15′), does not however exceed 1500 toises. In following the western slope of this system of mountains of Antioquia, we find that the point of partition of the waters that flow towards the South Sea, and the Caribbean Sea (in 5½° and 6° of latitude) corresponds nearly with the parallel of the isthmus of Raspadura, between the Rio San Juan and the Atrato. It is remarkable that, in this groupe more than 30 leagues broad, destitute of sharp summits, between 5¼° and 7° of latitude, the highest masses rise towards the west; while, further south, before the union of the two chains of Quindiu and Choco, we saw them on the east of Cauca.

The ramifications of the knot of Antioquia, on the north of the parallel 7° are very imper-

* Sierra de Abide of the geographer La Cruz, with the pretended volcano of Ebojito. (*See* above, vol. vi, p. 260, note.)

fectly known; it is observed only that their lowering is in general more rapid and complete towards the N.W., on the side of the ancient province of Biruquete* and Darien, than towards the N. and N. E., on the side of Zaragoza and Simiti. From the northern bank of the Rio Nare, near its confluence with the Samana, a counter-fort stretches out, known by the name of la Simitarra, and the mountains of San Lucar. We shall call it the *first branch* of the groupe of Antioquia. I saw it, in going up the Rio Magdalena, on the west, from the Regidor and the mouth of the Rio Simiti, as far as San Bartolome (on the south of the mouth of the Rio Sogamozo); while, towards the east, in 7½° and 8¼° of latitude, the counter-forts of the mountains of Ocana† appear in the distance; they are inhabited by some tribes of Molitone Indians. The *second branch* of the groupe of Antioquia (west of Samitarra) proceeds from the mountains of Santa Rosa, stretches between Zaragoza and Caceres, and terminates abruptly, at the confluence of the Rio Nechi (lat. 8° 33′), at least if the hills, often conical‡, between the

* See vol. vi. p. 249, note.

† The mountains of Ocaña, linked to the Sierra de Perija, branch from the eastern chain (that of Suma Paz) on the N. W. of Pamplona.

‡ I saw in sailing the *Tettas* of Cispata, Santero, Tolu, and San Martin (lat. 9° 18′-9° 32′).

mouth of the Rio Simu and the small town of Tolu; or even the calcareous heights of Turbaco and Popa, near Carthagena, may not be regarded as the most northern prolongation of this second branch. A *third*, advances towards the gulph of Uraba * or Darien, between the Rio San Jorge and the Atrato. It is linked towards the south, with the *Alto del Viento*, or Sierra de Abide, and is rapidly lost, in advancing as far as the parallel of 8°. Finally, the *fourth branch* of the Andes of Antioquia, placed on the west of Zitara and the Rio Atrato, undergoes, long before it enters the isthmus of Panama, such a depression, that between the gulph of Cupica, and the embarcadere of the Rio Naipipi, we find only a plain † across which M. Gogueneche has projected a canal of junction of the two seas. It would be interesting to know the configuration of the soil between cape Garachine, or gulph of St. Miguel, and cape Tiburon, above all, towards the source of the Rio Tuyra and Chucunaque, or Chucunque, in order to determine with precision where the mountains of the isthmus of Panama begin to rise, mountains of which the elevation does not appear to be above 100 toises high. The interior of Dar-

* See above, Vol. vi, p. 331; and *Semanario de Bogota*, Tom. ii, p. 83.

† Vol. vi, p. 256.

four is not more unknown to geographers, than the humid, insalubrious land, covered with thick forests, which extends on the north-west of Betoi and the confluence of Bevara with the Atrato, towards the isthmus of Panama. All that we hitherto know positively, is, that between Cupica and the left bank of the Atrato, there is either a *land-strait*, or a total absence of the Cordillera. The mountains of the isthmus of Panama may, by their direction and their geographical position, be considered as a continuation of the mountains of Antioquia and Choco; but on the west of Bas-Atrato, there scarcely exists a ridge in the plain. We do not find in this country a groupe of interposed mountains like that which indubitably links (between Barquesimeto, Nirgua, and Valencia) the eastern chain of New Grenada (that of Suma Paz and the Sierra Nevada de Merida) to the Cordillera of the shore of Venezuela.

In order the better to impress on the memory the results of my laborious researches on the structure and configuration of the Andes, I shall collect them in the form of a table, beginning with the most southern part of the New Continent. We shall see that the Cordillera of the Andes, considered in its whole extent, from the rocky breaker of Diego Ramirez, as far as the isthmus of Panama, is sometimes ramified into chains more or less

parallel, and sometimes *articulated* by immense *knots of mountains*. We distinguish nine of those knots, and consequently an equal number of branching points and ramifications. The latter are generally bifurcations: the Andes are twice only divided into three chains, in the knot of Huanuco, near the source of the Amazon, and the Huallaga, (lat. 10° to 11°,) and in the knot of the Paramo de las Papas (lat. 2°), near the source of the Magdalena and the Cauca. *Basins*, almost shut in at their extremities, parallel to the axis of the Cordillera, and bounded by two knots and two lateral chains, are characteristic features of the structure of the Andes. Among these knots of mountains, some, for instance those of Cuzco, Loxa, and Los Pastos, are 3300, 1500, and 1130 square leagues, while others no less important in the eyes of the geologist, are restrained to ridges or transversal dykes. To the latter belong the Altos de Chisinche (lat. 0° 40′ south), and the Los Robles (lat. 2° 20′ north), on the south of Quito and Popayan. The knot of Couzco, so celebrated in the annals of Peruvian civilization, presents a mean height of from 1200 to 1400 toises, and a surface nearly three times greater than the whole of Switzerland. The ridge of Chisinche, which separates the basins of Tacunga and Quito, is 1580 toises of absolute height, but scarcely a mile broad. The knots or groupes

which unite several partial chains, have not the highest summits, either in the Andes, or, for the most part, in the great Cordilleras of the ancient continent; it is not even certain that there is always in those knots a widening of the chain. The greatness of the mass, and the height so long attributed to points whence several considerable branches issue, was founded either on theoretic prejudices, or on false measures. Men amused themselves by comparing the Cordilleras to rivers that swell as they receive a number of tributary streams.

SOUTHERN HEMISPHERE.	KNOTS AND CHAINS OF THE ANDES IN SOUTH AMERICA.
Lat. 56° 33′	Rock of Diego Ramirez. Cape Horn. Patagonian Andes. Vestiges of the rocky isles of Huaytecas and Chonos. Cordilleras of Chili, reinforced on the east by the three
Lat. 33°—31°	Counter-forts of the Sierra de Cordova,
Lat. 27°—23°	of the Sierra de Salta,
Lat. 22°—18°	of the Sierra de Cochabamba and Santa Cruz.
Lat. 20½°—19¼°	KNOT OF PORCO AND POTOSI. Division in two chains, east and west of the basin of Titicaca: Eastern chain, or la Paz and Palca. | Western chain, or Tacna and Arequipa.
Lat. 15°—14°	KNOT OF COUZCO. Two chains, east and west of Rio Jauja, widened towards the east by the counter-fort of Beni. Eastern chain, or of Ocopa and Tarma. | Western chain, or of Huancavelica.
Lat. 11°—10½°	KNOT OF HUANUCO AND PASCO. Ramification in three chains separated by the basins of Huallaga and the Upper Maragnon. Eastern chain, or of Pozuzu and Muña. | Central chain, or of Pataz and Chachapoyas. Western chain, or of Guamachuco and Caxamarca.
Lat. 5¼°—3¼°	KNOT OF LOXA. Two chains, east and west of the basin of Cuenca.

SOUTHERN HEMISPHERE.	KNOTS AND CHAINS OF THE ANDES IN SOUTH AMERICA.
Lat. 2° 27′	KNOT OF ASSUAY. Two chains, on the east and west of the basin of Alausi and Hambato. Eastern chain, or of Cotopaxi. | Western chain, or of Chimborazo.
Lat. 0° 40′	KNOT (or rather ridge) OF CHISINCHE. Two chains, on the east and west of the valley of Quito. Eastern chain, or of Antisana. | Western chain, or of Pichincha.
NORTHERN HEMISPHERE.	The equator passes on the summit of Cayambe (belonging to the eastern chain or of Antisana.)
Lat. ½°—1¼°	KNOT OF LOS PASTOS. Ramification in two chains, on the east and west of the table-land of Almaguer.
Lat. 1° 55′—2° 20′	KNOT OF THE SOURCES OF THE MAGDALENA AND THE RIDGE OF LOS ROBLES. Three chains, divided by the basins of the Magdalena and Cauca. Eastern chain, or of Timana, Suma Paz, Chita, & Merida. | Central chain, or of Guanacas, Quindiu, and Erve. Western chain, with the platiniferous land of Choco.

NORTHERN HEMISPHERE.	KNOTS AND CHAINS OF THE ANDES IN SOUTH AMERICA.
Lat. 5½°—7°	KNOT OF THE PROVINCE OF ANTIOQUIA in which only the chains of Quindiu and Choco join. The eastern chain approaches by *counter-forts* towards Honda.
Lat. 7°—9°	Ramification of the knot of the mountains of Antioquia into four branches: 1st. of Simitarra; 2d. of Caceres, Nechi, and Altos de Tolu; 3d. between the Rio S. Jorge and the Atrato; 4th. on the west of the Atrato. This last branch, extremely low, appears to be linked at the utmost by an inconsiderable ridge, *(seuil,)* to the mountainous groupe of the isthmus of Panama. The eastern chain of the Andes of New Grenada, that of Suma Paz, and the Sierra Nevada of Merida, remains separated from the Sierra Nevada of Santa Marta, by the plains of Rio Cesar; but it joins, by the mountains Barquesimeto and Nirgua, the Cordillera of the shore of Venezuela, of which the culminant points are the Silla de Caraccas, the Bergantin, the Turimiquiri, and the promontory of Paria.

Among the basins which the sketch of the Andes presents, and which form probably as many lakes or small interior seas, the basins of Titicaca, Rio Jauja, and the Upper Maragnon, have respectively 3500, 1300, and 2400 square leagues of surface *. The first is so inclosed, that no drop of water can escape except by evaporation; it is a repetition of the shut up valley of Mexico †, and of those numerous circular basins which are discovered in the moon, and are sur-

* I shall state in this note the whole of those estimates which interest geologists. *Area* of the Andes, from the Land of Fire to the Paramo of las Rosas (lat. 9½° nor.), where the mountainous land of Tocuyo and Barquesimeto begins, part of the Cordillera of the shore of Venezuela, 58,900 square leagues, 20 to a degree; the four counterforts of Cordova, Salta, Cochabamba, and Beni alone, occupy 23,300 square leagues of this surface, and the three basins contained between the 6° and 20° of south latitude, 7200 square leagues. Deducting 33,200 square leagues for the whole of the inclosed basins and counterforts, we find in 65° of latitude, the area of the Cordilleras elevated in the form of walls, to be 25,700 square leagues, whence results (comprehending the knots, and admitting the inflexion of the chains,) a mean breadth of the Andes of 18 to 20 leagues. (*See* above, p. 409.) The valleys of Huallaga and the Rio Magdalena are not comprehended in these 58,900 square leagues, on account of the diverging direction of the chain, east of Chicoplaya and Santa Fe de Bogota.

† We consider it in its primitive state, without respect to the trench or cleft of the mountains, known by the name of *Desague de Huehuetoca.*

rounded by lofty mountains. An immense Alpine lake characterizes the basin of Tiahuanaco, or Titicaca; this phenomenon is so much more worthy of attention, as in South America those reservoirs of fresh water are almost entirely wanting, which are found at the foot of the Alps of Europe, on the northern and southern descent, and which are permanent during the season of drought. The other basins of the Andes, for instance, those of Jauja, the Upper Maragnon, and Cauca, pour their waters into natural canals, which may be considered as so many crevices placed either at one of the extremities * of the basin, or on its banks †, nearly in the middle of the lateral chain. It was proper to dwell on this *articulated form* of the Andes, on those knots or transversal ridges, and that long succession of inland basins, from Potosi in Upper Peru, as far as Salto de San Antonio in the province of Antioquia, because, in the continuation of the Andes called the Cordilleras of the shore of Venezuela, we shall find the same transversal dykes, and the same phenomena.

The ramification of the Andes and of all the

* Basin of the Amazon and Cauca.

† Basin of Tarma or the Rio Jauja, broken laterally on the east by the Mantaro. Basin of Almaguer, broken laterally on the west by the Rio de Patias.

great masses of mountains into several chains, merits particular consideration with respect to the height more or less considerable of the bottom of the inclosed basins, or longitudinal vallies. Geologists have hitherto been much more occupied by the successive narrowing of these basins, their depth compared with the walls of rock that surround them, and the correspondence between the re-entering and saliant angles, than by the level of the bottom of the vallies. No precise measure yet indicates the absolute height of the three basins, of Titicaca, Jauja, and the Upper Maragnon*; but I was fortunate enough to be able to determine the six other basins, or longitudinal vallies, which succeed each other, as by steps, towards the north. The bottom of the valley of Cuenca, between the knots of Loxa and Assuay, is 1350 toises; the valley of Alansi and of Hambato, between the knot of the Assuay and the ridge of Chisinche, 1320 toises; the valley of Quito † in

* I am inclined to believe that the southern part of the basin of the Upper Maragnon, between Huary and Huacarachuco, surpasses at least 350 toises; for I found the mean waters of Maragnon, near Tomependa, 194 toises above the level of the Ocean; and, according to the analogy of the course of the Magdalena, between Neiva and the Angostura of Cavare, the Upper Maragnon, may in a course of 4° of latitude, have a fall of 150 toises.

† The valley of Quito, Iaquito, and Tulubamba, ought to

the eastern part, 1340 toises; and in the western part 1490 toises; the basin of Almaguer 1160 toises; the basin * of the Rio Cauca, between the lofty plains of Cali, Buga, and Cartago, 500 toises; the valley of Magdalena, first between Neiva and Honda, 200 toises; and further on, between Honda and Mompox, 100 toises of mean height above the level of the sea †. In

be geognostically considered as the same valley as that of Puembo and Chillo. The interposed hills of Ichimbio and Poingasi mask this communication.

* In order to compare this basin, which is the most fertile part of the province of Popayan, and the basin of the Magdalena with those of the ancient continent, I shall here mention the table-lands of Mysore in India (420 to 470 toises); the interior of Spain (350 toises); of Switzerland between the Alps and the Jura (270 toises); of Bavaria (260 toises), and of Swabia (150 toises).

† In the region of the Andes comprehended between 4° of south latitude and 2° of north, the *longitudinal vallies*, or basins inclosed by parallel chains, are regularly between 1200 and 1500 toises high; while the transversal vallies are remarkable for their depression, or rather the rapid lowering of their bottom. The valley of Patias, for instance, running from N. E. to S. W. is only 350 toises of absolute height even above the junction of the Rio Guachicon with the Quilquasi, according to the barometric measures of Mr. Caldas; and yet it is surrounded by the highest summits, the Paramos de Puntaurcu and Mamacondy. (*Seman.* Tom. i, p. 28, and Tom. ii, p. 140.) In going from the plains of Lombardy, and penetrating into the Alps of the Tyrol, by a line perpendicular to the axis of the chain, we advance more than 20 marine leagues towards the north, yet we find the

this region, which has been measured with precision, the different basins lower from the equator, very sensibly towards the north. In general the elevation of the bottom of the inclosed basins merits great attention from those who reflect on the causes of the formation of the vallies. I do not deny that the depressions in the plains may be sometimes the effect of ancient pelagic currents, or slow erosions. I am inclined to believe that the transversal vallies, resembling crevices, have been widened by running waters; but these hypotheses of *successive erosions* cannot well be applied to the completely inclosed basins of Titicaca and Mexico. These basins, as well as those of Jauja, Cuenca, and Almaguer, which lose their waters only by a lateral and narrow issue, are owing to a cause more instantaneous, more closely linked

bottom of the valley of the Adige and of Eysack near Botzen, to be only 182 toises of absolute height, an elevation which exceeds but 117 toises that of Milan. (*See* above, Vol. iv. p. 311.) From Botzen however, to the ridge of Brenner (culminant point of 746 toises), is only 11 leagues. The Valais is a longitudinal valley; and in a barometric measurement which I made very recently from Paris to Naples and Berlin, I was surprised to find that from Sion to Brigg, the bottom of the valley only rises to from 225 to 350 toises of absolute height; nearly the level of the plains of Switzerland, which, between the Alps and the Jura, (for instance, between Berne, Thoun and Fribroug), are only from 274 to 300 toises.

with the heaving-up of the whole chain. It may be said that the phenomenon of the steeps or narrow declivities of Sarenthal and of the valley of Eysack in the Tyrol, is repeated at every step, and on a greater scale in the Cordilleras of equinoxial America. We seem to recognize those longitudinal sinkings, those "rocky vaults," which, to use the expression of a great geologist *, "are broken when extended over a great space, and leave deep and almost perpendicular rents."

If, to complete the sketch of the structure of the Andes, from the Land of Fire to the northern Polar Sea, we pass the limits of South America, we see the western Cordillera of New Grenada, after a great depression between the mouth of the Atrato and the gulph of Cupica, again rise in the isthmus of Panama to 80 or 100 toises high †, augmenting towards the west, in the Cordilleras of Veragua and Salamanca ‡,

* *Leopold de Buch, Tableau du Tyrol meridional*, 1823, p. 8.

† *See* above, Vol. vi, p. 254, 255.

‡ If what navigators affirm be true, that the mountains at the N. W. extremity of the republic of Columbia, and known by the names of Silla de Veragua, and Castillo del Choco (in the meridian of the Boca del Toro, and la Laguna Chiriqui), are visible at 36 leagues distance (*Pardy, Columbian Navigator*, p. 134), the elevation of their summits must be nearly 1400 toises, and would differ little from that of the Silla de Caraccas.

and extending by Guatimala, as far as the confines of Mexico. In this space it remains constantly near the coast of the South Sea, where, from the gulph of Nicoya to Soconusco (lat. 9½°—16°), is found a long series of volcanoes *, most frequently insulated, and sometimes linked to counter-forts or lateral branches. Passing the isthmus of Tehuantepec or Huasacualco, on the Mexican territory, the Cordillera of *central America* remains in the intendance of Oaxaca, at an equal distance from the two oceans; and then in 18½° to 21° of latitude, from Misteca to the mines of Zimapan, draws near the eastern coast. It attains nearly in the pa-

* *See* the list of twenty-one volcanoes of Guatimala, partly extinguished, and partly still burning, given by Mr. Arago and myself, in the *Annuaire du Bureau des longitudes pour* 1824, p. 175. No mountain of Guatimala having been hitherto measured, it is so much the more important to fix approximatively the height of the *Volcan de agua* placed between the Volcano of Pacaya, and the *Volcan de Fuego*, called also *Volcano of Guatimala*. Mr. Juarros expressly says, that this volcano, which destroyed by torrents of water and stones, on the 11th September, 1541, the Ciudad Vieja, or Almolonga, (the ancient capital of the country, which must not be confounded with the Antigua Guatimala), is covered with snow during several months of the year. This phenomenon seems to indicate a height of more than 1750 toises. (*Compendio de la Hist. de Guatimala*, Tom. i, p. 72—85; Tom. ii, p. 351. *Remesal, Hist. de la Province de San Vicente*, lib. iv, cap. 5.)

rallel of the town of Mexico, between Toluca, Xalapa, and Cordoba, its maximum of height; there, several colossal summits rise to 2400 and 2770 toises. Farther north, the chain called Sierra Madre * runs N. 40° W. towards San Miguel el Grande and Guanaxuato. Near the latter town (lat. 21° 0′ 15″), where the richest silver mines of the known world are found, it takes an extraordinary breadth, and is divided into three branches. The most eastern advances towards Charcas and the Real de Catorce, and lowers progressively (turning to the N.E.) in the ancient kingdom of Leon, in the province of Cohahuila and Texas. That branch stretches from the Rio Colorado de Texas, crossing the Arkansas, (on the west of Arkopolis) towards the confluence of the Mississipi and the Missouri (lat. 38° 51′). It bears the name in those countries of the *Mountains of Ozark* †, and attains 300 toises of height. An excellent observer, Mr. Edwin James, believes that on the east of the Mississipi (lat. 44°—46°), the Wisconsan Hills which

* In the north-east part of the ancient intendance of Mexico, between Zimapan, El Doctor and Ixmicuilpan.

† Ozark is at once the ancient name of Arkansas, and of the tribe of the Quawpaws Indians, who inhabit the banks of that great river. The culminant point of the *Mountains of Ozark* is in 37½° of latitude, between the sources of the White and Osage rivers. (*Long. Expedition to the Rocky Mount.*, 1823, Vol. ii, p. 80, 409, 423.)

stretch to the N.N.E. towards Lake Superior, may probably be a continuation of the mountains of Ozark. They seem to be characterized by their metallic wealth as a prolongation of the eastern Cordillera of Mexico. The western branch, or Cordillera, occupies a part of the province of Guadalaxara, and stretches by Culiacan, Aripe, and the auriferous lands of the Pimeria Alta and la Sonora, as far as the banks of the Rio Gila (lat. 33°—34°), one of the most ancient dwellings of the Aztèque nations. We shall soon see that this western chain appears to be linked by the counter-forts that advance towards the west, with the *maritime Alps of California*. Finally, the central Cordillera of Anahuac, which is the most elevated, runs first from south-east to north-west, by Zacatecas towards Durango, and afterwards from south to north, by Chihuahua, towards New Mexico. It takes successively the names of Sierra de Acha, Sierra de Los Mimbres, Sierra Verde, and Sierra de las Grullas, and joins towards the 29° and 30° of latitude, by counter-forts, two lateral chains, those of the Texas and la Sonora, which renders the separation of the chains more imperfect than the trifurcations of the Andes in South America.

That part of the Cordilleras of Mexico which is richest in silver beds and veins, is comprehended between the parallels of Oaxaca and

Cosiquiriachi (lat. 16½°—29°) the sole lands of produce or alluvial, that contain disseminated gold, extend still some degrees more towards the north *. It is a very striking phenomenon, that the gold-washing of Cinaloa and Sonora, like that of Barbacoas and Choco, on the south and north of the isthmus of Panama, is uniformly placed on the west of the central chain, on the descent opposite the Pacific Ocean. The traces of a still burning volcanic fire, which was no longer seen, on a length of 200 leagues, from Pasto and Popayan, to the gulph of Nicoya (lat. 1¼°—9½°), become very frequent on the western coast of Guatimala (lat. 9½°—16°); these traces of fire again cease in the mountains of gneis-granite of Oaxaca, and reappear, perhaps for the last time, towards the north, in the central Cordillera of Anahuac, between the 18½° and 19½° of latitude, where the volcanoes of Taxtla, Orizaba, Popocatepetl, Toluca, Jorullo, and Colima, appear to be placed on a crevice †

* According to the division of the mines of Mexico in eight groupes (*See my Polit. Essay*, Vol. iii, p. 123), the mines of Cosiquiriachi, Batopilas, and Parral, belong to the *groupe of Chihuahua*, in the intendance of Durango or New Biscay.

† On this *zone of volcanoes* is the parallel of the greatest heights of New Spain. (*See Polit. Essay*, Vol. i, p. 61.) If the survey of Captain Basil Hall (*Extracts from a Journal written on the coasts of Chili, Peru, and Mexico*, 1824,

which extends from E.S.E. to W.N.W., from one ocean to another. This line of summits, of which several enter into the limit of perpetual snows, and which are the loftiest of the Cordilleras from the peak of Tolima (lat. 40° 46′ nor.), is almost perpendicular to the great axis of the chain of Guatimala and Anahuac, advancing to the 27th parallel, constantly N. 42° E. It is, as I have observed above, a characteristic feature of every knot, or widening of the Cordilleras, that the grouping of the summits is independent of the general direction of the axis. The back of the mountains in New Spain form very elevated plains, where carriages can roll on a length of 400 leagues, from the capital to Santa-Fe and Taos, near the sources of Rio del Norte. This immense table-land, in 19° and 24½° of latitude, remains constantly at the height of 950 to 1200 toises, that is, at the elevation of the passages of the Great Saint Bernard and Splugen. We find on the back of the Cordilleras of Anahuac, which lower progressively from the town of Mexico towards Taos (northern limit of the *Provincias internas*),

Vol. ii, p. 379), yields results alike certain in latitude as in longitude, the volcano of Colima is on the north of the parallel of Puerto de Navidad, in 19° 36′ of latitude, and, like the volcano of Tuxtla, if not beyond the zone, at least beyond the *mean parallel* of the volcanic fire of Mexico, a parallel which appears to fall between 18° 59′, and 19° 12′.

a succession of basins: they are separated by hills little striking to the eye of the traveller because they rise but 250 to 400 toises above the surrounding plains. These basins are sometimes closed, like the valley of Tenochtitlan, where lie the great Alpine lakes, and sometimes present traces of ancient ejections, destitute of water.

Between lat. 33° and 38°, the Rio del Norte forms, in its upper course, a great longitudinal valley; and the central chain seems here to be divided into several parallel ranges. This disposition continues, towards the north, in the *Rocky Mountains* *, where, according to the intrepid labors of Captain Pike, Major Long, and Dr. Edwin James, between the parallels of 37° and 41°, several summits covered with eternal snows (Spanish Peak, James Peak, and Big-horn) †, are from 1600 to 1870 toises of abso-

* The *Rocky Mountains* have been known at different periods by the names of *Chypewyan, Missouri, Columbian, Caous, Stony, Shining* and *Sandy Mountains*. (*See Long. Exped.* Vol. ii, p. 405; and *Humb. Per. Narr.* Vol. iv, p. 9.)

† These peaks of amphibolic granite, do not form three insulated mountains; each peak has several pointed summits. *Spanish Peak*, (lat. 37° 20′ long. 106° 55′) is placed between the source of the northern branch (*Northern Fork*) of Canadian River, and the source of the Arkansas; it is perhaps the Sierra de Taos of the ancient Mexican maps, N.N.E. of Taos, (the Touis of Mellish, and of so many maps

lute height. Towards 40° of latitude, on the south of the sources of Padouca, a tributary

published in the United States). *Spanish Peak* is succeeded towards the north, by *James Peak* (38° 38′ lat. 107° 52′ long.) between the sources of the Arkansas and the Padouca, a tributary of the River Platte (*Ne-brasca*), that is, *shallow water*, in the language of the Otoes Indians, and not as marked on a new French map, Rio de la Plata, *rivière d'argent !*) Finally, in lat. 40° 3′, long. 108° 30′, between the two branches of the River Platte, rises the Bighorn, or Highest Peak, of Captain Pike, perhaps the Sierra Almagré of the inhabitants of New Mexico. The central mountain of these three great masses, James Peak, is estimated at 11,500 English feet (1798 toises) of absolute height; but this height trigonometrically measured, is only 8507 English feet (1330 toises): the height of the base above the level of the sea (468 toises) is not founded on a barometric measurement, but on the estimates, somewhat vague, of the descent of the three rivers Platte, Missouri, and Mississipi, (*Long. Exped.* Vol. ii, p. 32, 382. *Ap.* p. xxxviii). Captain Pike, from analogous hypotheses, but which are certainly not so good as those of Major Long and Mr. James, assigned 1250 toises of elevation to this table-land, or these plains at the back of the Rocky Mountains. Mr. James computes in two cuts, the loftiest summits of the Rocky Mountains to be, in 35° latitude, 10,500 English feet, (1642 toises); and in 41°, nearly 12,000 English feet (1876 toises). The lower limit of the perpetual snows appeared to him in 38½° latitude, to be 1530 toises, a height which, in the system of European climates, corresponds to 40° of latitude. The astronomical positions assigned by Major Long, to the eastern declivity of the Rocky Mountains (107° 20′ west of Paris, in 38° of latitude) appear to merit great confidence, the Peaks being

stream of the river Platte, a branch known by the name of the *Cotes Noires* * separates towards the north-east from the central chain. The Rocky Mountains seem at first to lower considerably in 46° and 48°; and then rise to 48° and 49°, where their tops are 1200 to 1300 toises, and their ridge near 950 toises. Between the sources of the Missouri and the river Lewis, one of the tributary streams of the Oregon or Columbia, the Cordilleras form, in widening, an elbow resembling the knot of Cuzco†. There also, on the eastern declivity of the Rocky Mountains, is the partition of water between the Caribbean Sea and the Polar Sea. This point corresponds with those which we have noted above, in the Andes of South America, on the counter-fort of Cochabamba, on the east, lat. 19° 20′ south; and in the Alto de los Ro-

linked by chronometric lines, and some observations of the satellites of Jupiter, at the Mississipi; but it must not be forgotten, that the place of those peaks relatively to Taos and Santa Fe of New Mexico, is much more uncertain. Lafora and Rivera differ 18′ in the lat. of Santa Fe, and the combinations from which I was able to deduce the difference of the meridians of Santa Fe and Mexico, are far from being satisfactory. (*See my Pol. Essay*, Vol. i, p. lxi.) I expect with impatience the observations made on the west of the peaks.

* *Black Hills*, which are 260 toises high; they stretch towards the parallel of 46°.

† *See* above, Vol. vi, p. 426.

bles (lat. 2° 20′ north), on the west. The ridge that separates the Rocky Mountains stretches from west to east, towards Lake Superior, between the basins of the Missouri, and that of the Lake Winnipeg and the Slave Lake. We have seen the central Cordillera of Mexico and the Rocky Mountains follow the direction N. 10° W., from 25° to 38° of latitude; the chain from that point to the Polar Seas is prolonged in the direction N. 24° W., and ends in the parallel 69°, at the mouth of the Mackenzie river*.

In thus developing the structure of the Cordilleras of the Andes from 56° south, to beyond the arctic circle, we have seen that its northern extremity (long. 130° 30′), is nearly 61° of longitude west of its southern extremity (long. 69° 40′); this is the effect of the long duration of a direction from S.E. to N.W. on the north of the isthmus of Panama. By the extraordinary breadth of the New Continent, in the 30° and 60° of north latitude, the Cordillera of the Andes, continually drawing nearer the western coast in the southern hemisphere, is

* The eastern boundary of the *Rocky Mountains* lies—

In 38°	latitude	107° 20′ longitude.
40°		108° 30′
63°		124° 40′
68°		130° 30′

removed 400 leagues on the north from the source of the River de la Paix. The Andes of Chili may be considered as the maritime Alps *, while, in their most northern continuation, the Rocky Mountains are a chain of the interior of a continent. There exists no doubt, between 23° and 60° of latitude, from the Cape Saint Lucas in California to Alaska, on the western coast of the Sea of Kamtschatka, a real Cordillera of the shore; but it forms, as we observed above †, a system of mountains almost entirely distinct from the Andes of Mexico and Canada. This system, which we shall call the *Cordillera of California, or of New Albion,* is linked between lat. 33° and 34° with the Pimeria alta, and the western branch of the Cordilleras of Anahuac; and between 45° and 53° of latitude, with the Rocky Mountains, by transversal ridges and counter-forts that widen towards the east. We shall learn from well-informed travellers who may one day pass over the unknown land between Cape Mendocino and the source of the Rio Colorado, if the connexion of the maritime Alps of California or New Albion, with

* A chain of the shore, geognostically speaking, is not a range of mountains that forms of itself the coast; this name is extended to a chain separated from the coast by a narrow plain.

† Vol. vi, p. 410, &c.

the western branch of the Cordilleras of Mexico, resembles that, which, notwithstanding the depression, or rather total interruption observed on the west of Rio Atrato, is admitted by geographers, between the mountains of the isthmus of Panama, and the western branch of the Andes of New Grenada. The maritime Alps, little elevated in the peninsula of Old California, rise progressively towards the north in the Sierra of Santa Lucia (lat. 34½°), in the Sierra of San Marcos (lat. 37°—38°) and in the snowy mountains near Cape Mendocino (lat. 39°—41°); the last seem to attain at least the height of 1500 toises. From Cape Mendocino, the chain follows the coast of the Pacific Ocean, but at the distance of from 20 to 25 leagues. Between the lofty summits of Mount Hood and Mount Saint Helen, in 45¼° latitude, it is broken by the great Rio Columbia. In New Hanover, New Cornwall, and New Norfolk *, these rents of a rocky coast are repeated, these geognostic phenomena of *fiords* that characterize western Patagonia, and Norway. Two volcanic peaks are placed where the Cordillera turns towards the west (lat. 58¼°, long. 139° 40′) †, one of which, Mount

* Harmon, Journal of Travels in the interior of North America, p. 78.

† Trigonometrical measurements made by the expedition of Malaspina, and which appear to deserve entire confidence,

Saint Elie, perhaps equals Cotopaxi in height; the other, Fair Weather Mountain, equals the height of Mount Rosa. The elevation of the former exceeds all the summits of the Cordilleras of Mexico and the Rocky Mountains, on the north of the parallel $19\frac{1}{4}°$; it is even the culminant point in the northern hemisphere, of the whole known world north of 50° of latitude. Towards the north-west of the peaks of Saint Elie and Fair-Weather, the chain of California widens considerably * in the interior of Russian America. The volcanoes multiply in number as we advance towards the west, in the peninsula of Alasca, and the Isles des Renards, where the volcano Ajagedan rises to the height † of 1175 toises above the level of the Ocean. It is thus that the chain of the maritime Alps of California, appears to be undermined by sub-

place Mount Saint Elie (lat. 60° 17′ 35″), and not, like Laperouse, at 1980 toises, but at 2793 toises; and Mount Fair-Weather, *Montana de Buentiempo*, in lat. 59° 0′ 42″, at 2304 toises. (*See Relacion del Viage al Estrecho de Fuca*, 1802, p. cxv and cxc. The little care bestowed on the publication of the voyage of Laperouse having caused many errors, which have been falsely attributed to that illustrious and unfortunate navigator (*Krusenstern, Reise um des Welt.*, Tom. ii, p. 15), it would be important to verify the measure of Mount Saint Elie on the manuscript of the journals brought back to France.

* *See my Pol. Essay on New Spain*, Vol. ii, p. 331.

† According to the measure of M. de Kotzebue.

terraneous fires, at its two extremities; towards the north, in 60° of latitude, and towards the south in 28° in the volcano of the Virgins*. If it were certain that the mountains of California belong to the western branch of the Andes of Anahuac, it might be said that the volcanic fire, still burning, abandons the central Cordillera when it removes from the coast, that is from the volcano of Colima; and that the fire is borne on the north-west by the peninsula of Old California, Mount Saint Elie, and the peninsula of Alaska, towards the Aleutes Islands, and Kamtschatka.

I shall terminate this sketch of the structure of the Andes, by recapitulating the principal features that characterize the Cordilleras on the north-west of Darien.

Lat. 8°-11°. Mountains of the isthmus of Panama, Veragua, and Costa Rica, slightly linked to the western chain of New Grenada, which is that of Choco.

Lat. 11°-16°. Mountains of Nicaragua and Guatimala; line of volcanoes N. 50° W., for the most part still burning, from the gulph of Nicoya to the volcano of Soconusco.

* Volcanes de las Virgenes. The highest summit of Old California, the Cerro de la Giganta (700 toises), appears to be also an extinguished volcano. (*Manuscript of Colonel Costanzo.*)

Lat. 16° 18°. Mountains of gneiss-granite in the province of Oaxaca.

Lat. 18½°-19½°. Trachytic knot of Anahuac, parallel to the Nevados and the burning volcanoes of Mexico.

Lat. 19½°-20°. Knot of metaliferous mountains of Guanaxuato and Zacatecas.

Lat. 21½-22°. Division of the Andes of Anahuac into three chains:

Eastern chain (of Potosi and Texas), continued by the mountains Ozark and Wisconsan, as far as Lake Superior.

Central chain (of Durango, New Mexico, and the Rocky Mountains,) sending, on the north of the source of the river Platte (lat. 42°), a branch (the Cotes Noires) towards the N. E., widening greatly between the parallels 46° and 50°, and lowering progressively as it draws near the mouth of Mackenzie river (lat. 68°).

Western chain (of Cinaloa and Sonora). It is linked by counter-forts to the maritime Alps, or mountains of California.

We have yet no means of judging with precision the elevation of the Andes on the south of the knot of the mountains of Loxa (south lat. 3° - 5°); but we know that on the north of that knot, the Cordilleras rise five times above the majestic height of 2600 toises:

In the groupe of Quito, 0° to 2° south lat. (Chimborazo, Antisana, Cayambe, Cotopaxi, Collanes, Yliniza, Sangai, Tunguragua.)

In the groupe of Cundinamarca, lat. 4½° north (peak of Tolima, on the north of the Andes of Quindiu).

In the groupe of Anahuac, from lat. 18° 59′ to 19° 12′ (Popocatepetl or Great Volcano of Mexico and Peak of Orizaba). If we consider the maritime Alps or mountains of California and New Norfolk, either as a continuation of the western chain of Mexico, that of Sonora, or, as being linked by counterforts to the central chain, that of the Rocky Mountains, we may add to the three preceding groupes:

The groupe of Russian America, from lat. 60° to 70° (Mont Saint Elie). On an extent of 63° latitude, I know only twelve summits of the Andes that reach the height of 2600 toises, and consequently surpass 140 toises the height of Mont Blanc. Three only of the twelve summits are placed on the north of the isthmus of Panama.

β. Insulated Groupe of the snowy Mountains of Santa Marta. In the enumeration of the different systems of mountains, I place this groupe before the chain of the shore of Vene-

zuela, although the latter, being a northern prolongation of the Cordillera of Cundinamarca, is immediately linked with the chain of the Andes. The *Sierra Nevada of Santa Marta* is contained within two divergent branches of the Andes, that of Bogota, and that of the isthmus of Panama. It rises abruptly like a fortified castle, amidst the plains extending from the gulph of Darien, by the mouth of the Magdalena, to the lake of Maracaybo. I have stated above* the ancient error of geographers, who have considered this insulated groupe of mountains covered with eternal snows, as the extremity of the high Cordilleras of Chita and Pamplona. The loftiest ridge of the Sierra Nevada de Santa Marta is only three or four leagues in length in the direction from east to west; it is bounded (at nine leagues distance from the coast,) by the meridians of the capes of San Diego and San Augustin. The culminant points, called El Picacho and Horqueta †, are placed near the western border of the groupe; they are entirely separated from the peak of San Lorenzo, alike

* Vol. vi, p. 396.

† According to the observations of M. Fidalgo (*Tierra firme, hoja tercera, Madrid*, 1817), the Horqueta is situated lat. 10° 51′, and long. 67° 29′ Cad., in supposing S. Marta 68° long. Cad.; it thence results, if with M. Oltmans, we adopt 76° 29′ Par. for the latter port, 75° 58′ Par. for the Horqueta.

covered with eternal snows, but only four leagues distant from the port of Santa Marta towards the S. E. I saw this latter peak from the heights that surrounded the village of Turbaco *, south of Carthagena. No precise measurement has hitherto ascertained the height of the Sierra Nevada, which Dampierre affirms to be one of the highest mountains of the northern hemisphere. Combinations founded on the *maximum* of distance at which the groupe is discovered at sea, yield more than 3004 toises of height †. This measure, notwithstanding the uncertainty of terrestrial refraction, would be less deficient if it had been made in the meridian of Horqueta, and if the errors of ship longitude did not render the distance to the snowy summits uncertain. The direct proof that the groupe of the mountains of Santa Marta are *insulated*, is found in the ardent climate of the lands *(tierras calientes)* that sur-

* Peak of San Lorenzo, according to Fidalgo, lat 11° 6′ 45″, long. 67° 50′ Cad. Turbaco, according to my observations, lat. 10° 18′ 5″, long. 77° 41′ 31″ Par. (The meridians of Cadiz and Paris differ 8° 37′ 37″.)

† *Pombo, Noticias varias sobre las Quinas*, 1824, p. 67 and 139. In this work, filled with useful knowledge, the latitude of the Peak of San Lorenzo is indicated at 10° 7′ 15″, instead of 11° 7′ 15″, an error so much the more dangerous, as the Horqueta is there called *la Sierra mas avanzada al mar*.

round them, on the east, towards the Rio Palomino; on the south, towards the villages of Valencia de Jesus and Santa Maria Ansola, towards the sources of the Rio Cesar, and towards the *Valle de Upar*, anciently known by the name of the Villa de Reyes; and on the west, towards the Aracataca *. Low ridges and a succession of hills indicate perhaps an ancient connection of the Sierra Nevada of Santa Marta on one side, by the *Alto de las Minas* † (on the west of Laguna Zapatosa) with the phonolitic and granitic rocks of Peñon and Banca ‡, and on the other, by the Sierra de Perija with the mountains of Chiliguana and Ocaña, which are the counter-forts § of the eastern chain of the Andes of New Grenada. In this latter chain the febrifuge species of quinquina *(corollis hirsutis, staminibus inclusis)* which advance most to the N. E., are those of the Sierra Nevada de Merida ||; but the real Cinchona, the most northern of South America, is found in the temperate region of the Sierra Nevada of Santa Marta.

* MSS. of General Cortes.

† It is a prolongation of the *Sierra Nevada* towards the S. W.

‡ On the banks of the Rio Magdalena, a little to the northward of Tamalameque and Regidor, of which I found the lat. 8° 30′, and the long. 76° 13′.

§ Vol. vi, p. 453.

|| Vol. vi, p. 210.

γ. Chain of the Shore of Venezuela. This is the system of mountains of which the configuration and direction have excited so powerful an influence on the state of cultivation and commerce of the ancient *Capitania general* of Venezuela. It bears different names (mountains of Coro, of Caraccas, of Bergantin, of Barcelona, of Cumana, and of Paria); but all these names belong to the same chain, of which the northern part runs constantly along the coast of the Caribbean Sea. It would be superfluous to repeat here that this system of mountains, which is 160 leagues long *, is a prolongation of the eastern Cordillera of the Andes of Cundinamarca. There is an immediate connection of the chain of the shore with the Andes, like that of the Pyrenees with the mountains of Asturia and Galicia; it is not the effect of transversal ridges, like the connection of the Pyrenees with the Swiss Alps, by the Black Mountain and the Cevennes. The points of junction, hitherto so ill indicated by the maps, are found between Truxillo, and the lake of Valencia. The following are the details of that junction.

We have observed above that this eastern chain of New Grenada stretches on the N. E. by the

* It is more than double the length of the Pyrenees from Cape Creuz to the point of Figuera.

Sierra Nevada de Merida, as well as by the four Paramos of Timotes, Niquitao, Bocono, and las Rosas, of which the absolute height cannot be less than from 1400 to 1600 toises. After the Paramo of las Rosas, which is more elevated than the two preceding, there is a great depression, and we no longer see a distinct chain or ridge, but a hilly ground *, and high table lands surrounding the towns of Tocuyo and Barquisimeto. We are ignorant of the height even of Cerro del Altar, between Tocuyo and Caranacatu; but we know by the recent measures of MM. Rivero and Boussingault, that the most inhabited spots are from 300 to 350 toises above the level of the Ocean. The limits of the mountainous land between Tocuyo and the vallies of Aragua are, the plains of San Carlos on the south, and the Rio Tocuyo on the north; the Rio Siquisique throws itself into that river. From the Cerro del Altar on the N. E. towards Guigue and Valencia, succeed, as culminant points †, the mountains of Santa Maria (between Buria and Nirgua); then the Picacho de Nirgua, supposed to be 600 toises high; and finally Las Palomeras and El Torito (between Valencia and Nirgua). The line of partition of water runs from west to east, from

* See above, Vol. iv, p. 248; vi, p. 209.

† MS. of General Cortes.

Quibor to the lofty savannahs of London, near Santa Rosa. The waters flow on the north, towards the *Golfo triste* of the Caribbean Sea; and on the south, towards the basins of the Apure and the Oroonoko. The whole of this mountainous country which we have just made known, and by which the chain of the shore of Caracas is linked to the Cordilleras of Cundinamarca, enjoyed some celebrity in Europe *, in the middle of the nineteenth century; for that part of this territory, formed of gneiss, granite, and lying between the Rio Tocuyo and the Rio Yaracui, furnishes auriferous veins of Buria, and the copper-mine of Aroa, which is still worked in our days. If, across *the knot of the mountains of Barquisimeto*, we trace the meridians of Aroa, Nirgua, and San Carlos, which are so near each other, we observe that the N. W. of that *knot* is linked with the Sierra de Coro, called also Sierra de Santa Lucia, and on the N. E. with the mountains of Capadare, Porto Cabello, and the Villa de Cura. It may be said to form the eastern wall of that vast circular depression of which the lake Maracaybo is the center, and which is bounded on the south and west, by the mountains of Merida, Ocaña, Perija, and Santa Marta.

The chain of the shore of Venezuela, of which

* Vol. iii, p. 528.

the existence was recognized by Pierre Martyr d'Anghiera *, presents towards the center, and the east, the same phenomena of structure which we have remarked in the Andes of Peru and New Grenada; namely, the division into several parallel ranks, and the frequency of longitudinal basins or vallies. But the irruptions of the Caribbean Sea having it appears, overwhelmed very anciently a part of the mountains of the shore, the ranks, or partial chains are interrupted, and some basins are become oceanic gulphs. To comprehend the Cordillera of Venezuela in mass, we must carefully study the direction and windings of the coast from Punta Tucacas (west of Porto Cabello), as far as Punta de la Galera of the island of Trinidad. That island, those of los Testigos, la Marguerita, and Tortuga, constitute, with the micaslates of the peninsula of Araya, the same system of mountains. The granitic rocks which shew themselves between Buria, Duaca, and Aroa †, cross the valley of the Rio Yaracui, and draw near the shore, whence they stretch, like a continued wall, from Porto Cabello to Cape Codera. This prolongation forms the *northern chain* of the Cordillera of Venezuela, and is traversed in going

* *Oceanica* (ed. 1531) Dec. 3, lib. iv, p. 52.

† On the east of San Felipe, in the *knot of the mountains* of Tocuyo and Barquisimeto.

from south to north, either from Valencia and the vallies of Aragua, to Burburata and Turiamo, or from Caraccas to La Guayra. The hot sources * issue from those flanks, those of Las

* *See* above, Vol. iii, p. 199; Vol. iv, p. 52, 167, 190, and 271. The other hot sources of the Cordillera of the shore, are those of S. Juan, Provisor, Brigantin, the gulph of Cariaco, Cumacatar, and Irapa. MM. Rivero and Boussingault, who visited the thermal waters of Mariara, in February, 1823, during their journey from Caraccas to Santa Fé de Bogota, found their *maximum* to be 64° cent. I found it at the same season, only 50·2°. Has the great earthquake of the 26th of March, 1812, had an influence on the temperature of these sources? The able chemists whom I have just mentioned, were struck like myself, with the great purity of the hot waters that issue from the primitive rocks of the basin of Aragua. "Those of Onoto, which flow at the height of 360 toises above the level of the sea, have no smell of sulphurated hydrogen; they are without taste, and cannot be precipitated, either by nitrate of silver or any reactive. When evaporated, they have an inappreciable residue, which consists of a little silica and a trace of alcali; their temperature is only 44·5°, and the bubbles of air which are disengaged intermittingly, are at Onoto, as well as in the thermal waters of Mariara, of *pure gaz azote* (*See* above, Vol. vi, p. 80). The waters of Mariara (244 toises) have a faint smell of sulphurated hydrogen; they leave by evaporation a slight residuum, that yields carbonic acid, sulphuric acid, soda, magnesia, and lime. The quantities are so small that the water is altogether without taste." (Letter of M. Boussingault to M. de Humboldt, in the *Annales de Phys. et de Chimie*, tom. xxvi, p. 81.) During my journeys I found the source of the Comangillas only, (near Guanaxuato in

Trincheras (90·4°) on its southern slope, and those of Onoto and Mariara on its southern slope. The former issue from a granite with large grains, very regularly stratified; the latter from a rock of gneiss. What especially characterizes the *northern chain*, is a summit which is not only the loftiest of the system of the mountains of Venezuela, but of all South America, on the east of the Andes. The eastern summit of the Silla of Caraccas, according to my barometric measurement, made in 1800, is 1350 toises high *. MM. Boussingault and Rivero carried an excellent barometer of Fortin, in 1822, on this very summit, which they found to be from 1351½ toises; this proves that notwithstanding the commotion which took place on the Silla during the great earthquake

Mexico, still hotter than the thermal waters of las Trincheras, situated on the south of Porto Cabello. The waters of Comangillas flow at 1040 toises high, and are alike remarkable for their purity, and their temperature of 96·3° cent.

* Vol. iii, p. 505; Vol. iv, p. 21. The Silla of Caraccas is only 80 toises lower than the Canigou in the Pyrenees. As Caraccas, Santa Fe de Bogotá, and Quito, may be considered as the three capitals of Columbia, I shall here repeat, in order to establish a precise comparison of the height of those three towns, that the inhabitants of Caraccas recognize at once in the summit of the Silla which commands their town, the level of the plains of Bogota, and a point of 150 toises, which is less elevated than the great square of Quito.

of Caraccas, that mountain did not sink 50 or 60 toises, as several North American journals asserted. Four or five leagues south of the *northern chain*, which is that of Mariara, la Silla, and Cape Codera, the mountains of Guiripa, Ocumare, and Panaquire, form the *southern chain* * of the coast, which stretches in a parallel direction from Guigue to the mouth of the Rio Tuy, by the Guesta of Yusma, and the Guacimo. The latitudes of the Villa de Cura and San Juan, so erroneously placed on our maps, enabled me to ascertain the mean breadth of the whole Cordillera of Venezuela. Ten or twelve leagues † may be counted from the descent of the northern chain which bounds the Caribbean Sea, to the descent of the southern chain which bounds the immense basin of the Llanos. This latter chain, designated also by the name of the *Inland Mountains*, is much lower than the northern chain; and I scarcely believe that the Sierra de Guayraima attains the height of 1200 toises, although this has been recently affirmed.

The two partial chains, that of the interior, and that which lies along the coast, are linked

* Vol. iv, p. 107, 269, 273.

† The breadth is very considerable towards the east, regarding the Cerro de Flores (lat. 9° 26′) south-west of Parapara and Ortis, as placed on the limit of the Llanos de Calabozo.

by a ridge or knot of mountains * known by the names of Altos de las Cocuyzas (845 t.) and the Higuerote (835 t.) between Los Teques and La Victoria, in 69° 30′ and 69° 50′ of longitude. On the west of this ridge lies the basin, entirely inclosed †, of the lake of Valencia or the *Valles de Aragua*; and on the east, the basin of the Caraccas and of the Rio Tuy. The bottom of the former of these basins is from 220 to 250 toises high; the bottom of the latter is 460 toises above the waters of the Caribbean Sea. It results from these measures, that the most western of the two longitudinal vallies of the Cordillera

* Vol. iv, p. 77, 80.

† This basin contains a *small system of inland rivers*, which do not communicate with the Ocean. The southern chain of the Cordillera of the shore of Venezuela is so depressed towards the south-west, that the Rio Pao is separated from the tributary streams of the lake of Tacarigua or Valencia (Vol. iv, 149 and 154). Towards the east, the Rio Tuy, which takes its rise on the western declivity of the knot of mountains of Las Cocuyzas, appears at first to throw itself into the vallies of Aragua; but hills of calcareous tuf, forming a ridge between Consejo and Victoria (Vol. iv, p. 80), force it to take its course south-east. In order to rectify what is said above (Vol. iv, p. 162, note *) on the composition of the waters of the lake of Valencia, I shall here mention that MM. Boussingault and Rivero found no traces in them of nitre of potash, but $\frac{1}{2000}$ of carbonat of soda and of magnesia, muriate of soda and sulfate and carbonate of lime.

of the shore is the deepest; while in the plains near the Apure and the Oroonoko, the declivity is from west to east; but we must not forget that the peculiar disposition of the bottom of the two basins, which are bounded by two parallel chains, is a local phenomenon altogether separate from the causes on which the general structure of the country depends. The eastern basin of the Cordillera of Venezuela is not shut up like the basin of Valencia. It is in the knot of the mountains of Las Cocuyzas, and of Higuerote, that the Serrania de los Teques and Oripoto, stretching towards the east, form two vallies, those of the Rio Guayre and Rio Tuy; the former contains the town of Caraccas, and both unite below the Caurimare. The Rio Tuy runs through the rest of the basin, from west to east, as far as its mouth, which is situated on the north of the mountains of Panaquire.

The northern range of the mountains of the shore of Venezuela seems to terminate at Cape Codera; but this is only an apparent interruption *. The coast forms a vast nook, thirty-five marine leagues in length, at the bottom of which is the mouth of the Rio Unare, and the road of Nueva Barcelona. Stretching first from west to east, in the parallel of 10° 37′, this coast draws in at the parallel 10° 6′, and re-

* Vol. ii, p. 262.

sumes its ancient direction (10° 37′—10° 44′) from the western extremity of the peninsula of Araya, to the eastern extremity of Montaña de Paria and the island of Trinidad. It results from this position of the coast, that the range of mountains near the shore of the provinces of Caraccas and Barcelona, between the meridian 66° 32′ and 68° 29′, and which I saw on the south of the bay of Higuerote; and on the north of the Llanos * of Pao and Cachipo, must be considered as the continuation of the *southern chain of Venezuela*, and as being linked towards the west with the Sierras de Panaquire and Ocumare. The chain of the interior consequently, between Cape Codera and Cariaco, forms itself the coast. This range of very low mountains, often interrupted from the mouth of the Rio Tuy to that of the Rio Neveri, rises abruptly on the east of Nueva Barcelona, first in the rocky island of Chimanas †, and then in the *Cerro del Bergantin*, elevated probably more than 800 toises, but of which the astronomical position and the precise height are yet alike unknown ‡. The northern chain (that of

* Vol. iii, p. 375, 376; Vol. vi, p. 53 and 68.

† Vol. iii, p. 357; Vol. vi, p. 85.

‡ Vol. ii, p. 206; Vol. iii, p. 94. The peak of Cumanacoa, which the five maps of the *Deposito hydrografico* of Madrid place lat. 10° 7′, is perhaps the Turimiquiri; for

Cape Codera and the Silla of Caraccas) reappears on the meridian of Cumana. The micaceous-slate of the peninsula of Araya and Maniquarez* are joined by the ridge or *knot of mountains of Meapire* †, to the southern chain, that of Panaquire, Bergantin, Turimiquiri, Caripe, and Guacharo ‡. I have mentioned in another place, that this ridge, not more than 200 toises of absolute height, has, in the ancient revolutions of our planet, prevented the irruption of the Ocean, and the union of the gulphs of Paria and Cariaco. On the west of Cape Codera, the northern chain, composed of primitive granitic rocks, displays the loftiest summits of the whole Cordillera of Venezuela; but the culminant points on the east of that Cape, are composed in the southern chain, of secondary calcareous rocks. We have seen above, that the peak of Turimiquiri, at the back of the Cocollar §, is 1050 toises, while the bottom of the high valleys of the convent of Caripe ‖, and of Guardia de San Augustin, are 412 and 533 toises of absolute height. On the east of the ridge of Mea-

the town of Cumanacoa, according to my observations, is 10° 16′ 11″.

* Vol. ii, p. 362; Vol. vi, p. 92, &c.

† Vol. ii, p. 260; Vol. iii, p. 183.

‡ Vol. iii, p. 174.

§ Vol. iii, p. 94.

‖ Vol. iii, p. 115.

pire, the southern chain sinks abruptly towards the Rio Arco and the Guarapiche; but, in quitting the main land, we see it again rise on the southern coast of the island of Trinidad, which is but a detached portion of the continent, and of which the northern side indubitably displays the vestiges of the northern chain of Venezuela, that is of the Montana de Paria (the Paradise of Christopher Columbus), the peninsula of Araya, and the Silla of Caraccas. The observations of latitude I made at the Villa de Cura (10° 2′ 47″), the farm of Cocollar (10° 9′ 37″), and the convent of Caripe (10° 10′ 14″), compared with the position more anciently known of the southern coast of Trinidad (lat. 10° 6′) prove, that the southern chain, south of the basins of Valencia and of Tuy * and of the gulphs of Cariaco and Paria, is still more constant in the direction from west to east than the northern chain from Porto Cabello to Punta Galera. It is highly important to know the southern limit of the *Cordillera of the shore of Venezuela*, because it determines the parallel at which the *Llanos* or

* The bottom of the first of these four basins bounded by parallel chains, is from 230 to 460 toises above, and that of the two latter from 30 to 40 toises below the present level of the sea. Hot waters gush from the bottom of the gulph of the basin of Cariaco (Vol. iii, p. 199), as from the bottom of the basin of Valencia on the continent (Vol. iv, p. 167).

the savannahs of Caraccas, Barcelona, and Cumana begin. Geographers, who are fond of copying, and of stereotyping, for ages, the chains of mountains and the branches of rivers which the caprice of the draftsman has traced on some well-known maps, never cease to figure, between the meridians of Caraccas and Cumana, two Cordilleras stretching from north to south, as far as 8½° of latitude; to which they give the names of Cerros de Alta Gracia, and del Bergantin *; thus rendering a territory of

* *See* all the French, English, and German maps published before the *Map of Columbia*, by M. Brué (1823), for which a part of the materials were employed, which I had collected on the extent and direction of the chains of mountains. The source of the error which we find in Nicolosio, Sanson (1669), and De l'Isle (1700), must be attributed to the practice of the first geographers of America, of enlarging beyond measure, the breadth of the Andes of Peru and New Grenada, and placing them so far towards the east, that Quito is sometimes found on the meridian of Cumana (Vol. v, p: 853). In this manner, the steppes of Venezuela were covered with mountains that linked the *groupe of the Parime* with the chains of the shore of Caraccas. De l'Isle places the *Valley of Sayma* near the range of mountains which Sanson had marked as going from *north to south*, from Barcelona to the Oroonoko; this proves that he had some confused idea of the mountains of Caripe, inhabited by the Chaymas Indians. D'Anville, according to systematic ideas on the origin of rivers, figures a ridge between the sources of the Unare, the Guarapiche, the Pao, and the Manapire (Vol. iv, p. 301). This is the pattern

25 leagues broad, mountainous, where we should seek in vain a mound of a few feet in height.

In fixing our eyes on the Island of Marguerita, composed, like the peninsula of Araya, of micaceous slate, and anciently linked with that peninsula by the Morro de Chacopata and the isles of Coche and Cubagua *, we are inclined to recognize in the two mountainous groupes of Macanao and la Vega de San Juan, the traces of a third chain of the Cordillera of the shore of Venezuela. Do these two groupes of Marguerita, of which the most westerly is above 600 toises high †, belong to a sub-marine chain stretching by the isle of Tortuga, towards the Sierra de Santa Lucia de Coro, on the parallel of 11°? Must we admit, that in 11¼° and 12½° of latitude, a fourth chain, the most northerly of all, stretched heretofore by the island of Hermanos, by Blanquilla, the Orchila, Los Roques, Aves, Buen Ayre, Curacao, and Oruba, towards Cape Chichivacoa? These important problems can only be solved when this chain of islands parallel to the coast have been examined by a well-informed geognost. It must not be for-

which has been hitherto followed, and from which Surville himself has not ventured to deviate in his map subjoined to Caulin's work.

* *See* Vol. vi, p. 94.

† Vol. ii, p. 46.

gotten, that one great irruption of the Ocean appears to have taken place between Trinidad and Grenada*, and that no where else in the long series of the Little Antilles, two neighbouring islands are so far removed from each other. We recognize the effect of the *current of rotation* in the direction of the coast of Trinidad, as in the coasts of the provinces of Cumana and Caraccas, between Cape Paria and Punta Araya, and between Cape Codera and Porto Cabello †. If a part of the continent has been overwhelmed by the Ocean on the north of the peninsula of Araya, it is probable, that the enormous sand-bank which surrounds Cubagua, Coche, the island of Marguerita, Los Frailes, la Sola, and the Testigos, marks the extent and outline of the submerged land. This sand-bank or *placer* of 200 square leagues, is only well

* It is affirmed that the island of Trinidad is traversed in the northern part by a chain of primitive slate, and that Grenada furnishes basalts. It would be important to examine of what rock the island of Tobago is composed; it appeared to me of a dazzling whiteness (Vol. ii, p. 27; Vol. iv, p. 45); and on what point, in going from Trinidad towards the north, the trachytic and trapean system of the Little Antilles begins.

† The same effects of the current of rotation, and the same regular direction E. and W., may be remarked opposite the coast of the main-land, on the shore of Portorico, of Haiti or Saint-Domingo and the island of Cuba, between the Punta Maysi and Cabo Crux.

known in all its extent, by the tribe of the Guayqueries; it is frequented by these Indians on account of its abundant fishery in calm weather. The *Gran Placer* is believed to be separated only by some canals or deeper furrows of the bank of Grenada, which have almost the same form as the island of that name, from the sand-bank that extends like a narrow dyke, from Tobago to Grenada, and which is recognized by the lowering of the temperature of the water*; finally, from the sand-banks of Los Roques and Aves. I know that able navigators deny these communications, because they consider the bottom of the sea in a different point of view from the geologist. Marine maps appropriated to the wants of navigation, indicate no banks where there are 50 or 60 toises of water; but what is so slight a depression in the eyes of one who seeks to study the inequalities of the surface of the globe, in mass, below, and above the level of the sea? The Guayqueries Indians, and the inhabitants in general of the coast of Cumana and Barcelona, are imbued with the idea that the water of the sand-banks of Marguerita and the Testigos diminishes from year to year; they believe that in the lapse of ages, the Morro de Chacopata on the peninsula of Araya, will be joined by a neck

* Vol. ii, p. 28.

of land, to the isles of Lobos and Coche. The partial retreat of the waters on the coast of Cumana * is incontestable, and the bottom of the sea has been raised † at several epochs, by the effect of earthquakes; but these local phenomena, already so difficult to explain by the action of volcanic force, the changes in the direction of currents, and the swelling of the waters which are the necessary consequences, are still far removed from the effects which are manifested at once on several hundred square leagues.

3. Group of the Mountains of Parime. It is essential to mineralogical geography to designate by one name the whole of the mountains that form one system. In order to attain this end, a denomination which belongs only to a partial groupe, might be extended over the whole chain; or a name employed, not susceptible by its novelty of giving rise to homogenic mistakes. We know how confused the orography of the interior of Asia has remained, from the obstinacy with which the vague names of Mustag, properly called Mussur, have so long been preserved. The mountaineers designate every

* Vol. iii, p. 194.

† Vol. ii, p. 220. Compare also Bollingbroke, Voyage to Demerary, p. 201. Ideas of the progressive and continued heaving-up of the land prevails also in Sweden and the Molucca islands.

88186

groupe by a peculiar denomination; and a chain is generally considered as forming a whole, only when it is discovered from afar bounding the horizon of the plains. We find the names of *snowy mountains*, repeated in every zone (Himalaya, Imaus), *white* (Alpes, Alb), *black and blue*. The greater part of the *Sierra Parime* is in some sort turned by the Oroonoko. I have, however, avoided a denomination which alludes to this circumstance, because the groupe of mountains I have to make known, extends far beyond the banks of the Oroonoko. It stretches to the south-east, towards the banks of the Rio Negro, and the Rio Branco, to the parallel of 1½° of north latitude. The geographical name of the Parime *, has the advantage of recalling the fable of Dorado, and the lofty mountains † which, from the sixteenth century, were supposed to surround the lake Rupunuwini, or the *Laguna de Parime*. The missionaries of the Oroonoko still give the name of Parime to the whole of the vast mountainous country comprehended between the sources of the Erevato, the Oroonoko, the Caroni, the Rio Parime ‡, (a tributary of the Rio Branco), and

* Vol. v, p. 570, 780, 790.

† Vol. v, p. 841.

‡ The Rio Parime, after having received the waters of the Uraricuera, joins the Tacutu, and forms near the fort of

the Rupunuri or Rupunuwini, a tributary of the Rio Essequibo. This country is one of the most unknown parts of South America, and is covered with thick forests and savannahs; it is inhabited by independent Indians, and crossed by rivers of dangerous navigation, on account of the frequency of the bars and cataracts.

The *system of the mountains of Parime*, separate the plains of the Lower Oroonoko from those of the Rio Negro, and the Amazon; it occupies a territory of trapezoide form, comprehended between the parallels of 3° and 8°; and the meridians of 61° and 70½°. I indicate here only the elements of the loftiest groupe, for we shall soon see that towards the south-east, the mountainous country, in lowering, draws near the equator, and the French and Portugueze Guyanas. The *Sierra Parime* extends most in the direction N. 85° W. and the partial chains in which it divides towards the west, generally follow the same direction. It is less a Cordillera or a continued chain in the sense given to those denominations when applied to the Andes and Caucasus, than an irregular grouping of mountains separated from each other by plains and savannahs. I visited the northern, western, and southern part of the

San Joacquim, the Rio Branco, one of the tributary streams of the Rio Negro.

Sierra Parime, which by its position, and its extent of more than 25,000 square leagues, well deserves to be withdrawn from the neglect in which it has been so long buried. It remains from the confluence of the Apure as far as the delta of the Oroonoko, constantly three or four leagues removed from the right bank of the great river; only some *arrotes*, or rocks of gneiss-granite, amphibolic-slate, and greenstone advance as far as the bed of the Oroonoko, and give rise to the rapids of Torno and of la Boca del Infierno *. I shall name successively from N.N.E. to S.S.W. the different chains which Mr. Bonpland and myself recognized in proportion as we approached the equator and the river of the Amazons. 1st. The most northern chain of the whole system of the mountains of Parime, appeared to us to be that which stretches (lat. 7° 50′), from the Rio Arui, in the meridian of the rapids of Camiseta, at the back of the town of Angostura, towards the great cataracts of the Rio Carony and the sources of the Imataca. In the missions of the Catalan Capucins,

* Vol. v, p. 607. To this series of advanced rocks those also belong which pierce the soil between the Rio Aquire and the Rio Barima; the granitic and amphibolic rocks of the Vieja Guayana and of the town of Angostura, the Cerro de Mono, on the south-east of Muitaco or Real Corona; the Cerro of Taramuto, near the Alta Gracia, &c. (Vol. v, p. 690, 754.)

this chain, which is not 300 toises high, separates the tributary streams of the Oroonoko and those of the Rio Cuyuni, between the town of Upata, Cupapui, and Santa Marta *. On the west of the meridian of the rapids of Camiseta (long. 67° 10′), the high mountains in the basin of the Rio Caura, only commence at 7° 20′ of latitude, on the south of the mission of San Luis Guaraguaraico, where they produce the rapids of Mura. This chain stretches towards the west by the sources of the Rio Cuchivero, the Cerros del Mato †, the Cerbatana and Maniapure, as far as *Tepupano*, a groupe of granitic rocks of strange forms, that surround the Encaramada. The culminant points of this chain (lat. 7° 10′ — 7° 28′) are placed, according to the information I gathered from the Indians, near the sources of Caño de la Tortuga. The *chain of the Encaramada* ‡, displays some traces of gold. It is also celebrated in the mythology of the Tamanaques; for the painted rocks it contains are associated with ancient geogonic traditions. The Oroonoko changes its direction at the confluence of the Apure, breaking a part of the chain of the Encaramada; the monticules and

* Vol. v, p. 760.

† Pl. 15, 16, and 20 of the Geographical Atlas, and the *Personal Narrative*, Vol. v, p. 673.

‡ Vol. iv, p. 460, 470; Vol. v, p. 827.

the scattered rocks in the plain of Capuchino *, and on the north of Cabruta, may be considered either as the vestiges of a destroyed *counterfort*, or, (on the hypothesis of the igneous origin of granite,) as partial eruptions and heavings up. I shall not here discuss the question, whether the most northerly chain, that of Angostura and of the great fall of Carony, be a continuation of the chain of Encaramada. 3d. In navigating on the Oroonoko from north to south, we see small plains and chains of mountains † alternately on the east, of which we cannot distinguish the profiles, that is the section perpendicular to their longitudinal axis. From the mission of the Encaramada to the mouth of the Rio Qama, I reckoned seven times this alternating of savannahs, and high mountains. First, on the south of the isle Cucuruparu, rises the *chain of Chaviripe* (lat. 7° 10′); it stretches, inclining towards the south (lat. 6° 20′ — 6° 40′), by the Cerros del Corozal, the Amoco, and the Murcielago, as far as the Erevato, a tributary stream of the Caura. It there forms the rapids of Paru ‡, and is linked with the summits of Matacuna. 4th. The chain of Chaviripe is succeeded by that of Baraguan (lat. 6° 50′ — 7° 5′), celebrated for the strait of the Oroonoko to which it gives

* Vol. v, p. 675.

† Vol. iv, p. 468.

‡ Vol. v, p. 685.

its name. The Saraguaca, or mountain of Uruana, composed of detached blocks of granite, may be regarded as a northern counter-fort of the chain of Baraguan *, stretching on the south-west towards Siamacu, and the mountains (lat. 5° 50′) that separate the sources of the Erevato and the Caura from those of the Venituari. 5th. *Chain of Carichana and of Paruaci* (lat. 6° 25′), of a wild aspect, but surrounded by charming meadows. Piles of granite crowned with trees, and insulated rocks of prismatic form, (the Mogote of Cocuyza, and the Marimaruta † or *Castillito* of the jesuits), belong to this chain. 6th. On the western bank of the Oroonoko, which is low and flat, the Peak of Uniana rises abruptly more than 3000 feet high. The *counter-forts* (lat. 5° 35′ — 5° 40′) which this peak sends towards the east are crossed by the Oroonoko in the *first Great Cataract* (that of Mapura or the Atures); further on they join, and rising in a chain, stretch ‡ towards the sources of the Cataniapo, the rapids of Venituari, situated on the north of the confluence of the Asisi (lat. 5° 10′) and the Cerro Cunevo. 7th. Five leagues south of the Atures is the *chain of Quittuna* §, *or of May-*

* Vol. iv, p. 502; Vol. v, p. 554, 604.

† Vol. iv, p. 540, 544.

‡ Vol. v, p. 43, 55, 119.

§ Vol. v, p 133, 166, 167, 554.

pures (lat. 15° 13′), which forms the bar of the *Second Great Cataract.* None of those lofty summits are placed on the west of the Oroonoko; on the east of that river rises the Cunavami, the truncated peak of Calitamini, and the Jujamari, to which father Gili attributes an extraordinary height. 8th. The last chain of the south-west part of the Sierra Parime is separated by woody plains from the chain of Maypures; it is that of the Cerros de Sipapo (lat. 4° 50′), an enormous wall, behind which the powerful chief of the Guaypunabis Indians intrenched himself during the expedition of Solano. The *chain of Sipapo* * may be considered as the beginning of the range of lofty mountains that bound, at the distance of some leagues, the right bank of the Oroonoko, where it runs from S. E. to N. W. between the mouth of the Venituari, the Jao, and the Padamo (lat. 3° 15′). In going up the Oroonoko, above the cataract of Maypures, long before we reach the point where it turns, near San Fernando del Atabapo, we find the mountains are removed from the bed of the river†, and from the mouth of the Zama there are only insulated rocks in the plains. The chain of Sipapo (if we consider the lofty summits as making a part of it,

* Vol. v, p. 174.

† Vol. v, p. 193.

which are seen constantly on the north * in navigating from Santa Barbara to the Esmeralda), forms the south-west limit of the system of mountains of Parime, between the 70½° and 68° of longitude. The modern geognosts have observed that the culminant points of a groupe are placed less frequently at its centre than towards one of its extremities, preceding, and announcing in some sort, a great depression † of the chain. This phenomenon is again observed in the groupe of the Parime, the loftiest summits of which, the Duida and the Maraguaca, are in the range of the most southerly mountains, where the plains of Cassiquiare and Rio Negro begin.

These plains or savannahs, which are not covered with forests in the vicinity of the rivers, do not, however, display the same uniform continuity as the Llanos of the Lower Oroonoko, of the Meta, and of Buenos Ayres. They are interrupted by groupes of hills (Cerros de Daribapa ‡,) and by insulated rocks of grotesque forms §

* Vol. v, p. 613.

† Montblanc, Chimborazo.

‡ Lat. 3°, long. 69° 12′ between the Itiniveni or Conanchite and the sources of the Tama, a tributary stream of the Alacavi and the Atabapo.

§ Piedra de Kemarumo (lat. 3° 20′), Piedra de la Guahiba, Piedra de Astor, on the banks of the Atabapo; rocky wall of Guanari with two towers near the Rapids of Cunanivacari,

that pierce the soil, and fix from afar the attention of the traveller. These granitic, and often stratified masses, resemble pillars or edifices in ruins. The same force which heaved up the whole groupe of the Sierra Parime, has acted here and there in the plains as far as beyond the equator. The existence of these steeps and sporadic monticula, renders difficult the precise fixation of the limits of a system in which the mountains are not longitudinally ranged as in a vein. In proportion as we advance towards the frontier of the Portugueze province of Rio Negro the high rocks become more rare, and we no longer find the shelves or dykes of gneis-granite which cause rapids and cataracts in the rivers.

Such is the surface of the soil between the 68½° and 70½° of longitude, between the meridian of the bifurcation of the Oroonoko, and that of San Fernando de Atabapo; further on, westward of the Upper Rio Negro, towards the source of that river, and its tributary streams the Xiè and the Uaupes (lat. 1°—2¼°, long. 72° —74°) lies a small mountainous table-land, in which Indian traditions place a *Laguna de oro*, that is a lake surrounded with beds of aurife-

Piedra de Culimacari (lat. 2° 0′ 42″) on the banks of the Cassiquiare; Glorieta de Cocuy (lat. 1° 40′) and Piedra de Uinumane on the banks of the Rio Negro. (*See* Vol. v, p. 233, 242, 371, 372, 399, 400, 409, 412.)

rous earth *. At Maroa, the most westerly mission of the Rio Negro, the Indians assured me that that river, as well as the Inirida (a tributary stream of the Guavare), rises at the distance of five days march, in a country bristled with hills and rocks. The natives of San Marcellino speak of a Sierra Tunuhy, placed near thirty leagues west of their village, between the Xie and the Icanna. M. de Condamine heard also from the Indians of the Amazon, that the Quiquiari (Iquiari of Acuna and Fritz), comes from "a country of mountains and mines." Now, the Iquiari is placed by the French astronomer, between the equator and the mouth of the Xie (Ijié), which identifies it with the Iguiare that falls into the Icanna. We cannot advance in the geognostic knowledge of America, without having unceasingly recourse to the re-

* Vol. v, p. 312, 320, 330. According to the journals of Acuna, and Firtz, the Manaos Indians (Manoas) drew gold from the banks of the Yquiari (Iguiare or Iguare), of which they made blades. The manuscript notes of Don Apollinario also make mention of the gold of the Rio Uaupes. (La Condamine, *Voyage à l'Amazone*, p. 98, and 129; and above, Vol. v, p. 313, 320, 664.) We must not confound the *Laguna de Oro*, which is said to be found in going up the Uaupes (nor. lat. 0° 40′) with another *gold lake* (south lat. 1° 10′) which La Condamine calls *Marahi* or *Marachi* (water), and which is nothing but a soil often inundated, between the sources of the Jurubech (Urubaxi) and the Rio *Marahi*, a tributary stream of the Caqueta.

searches of comparative geography. The small system of mountains, which we shall call provisionally, that of the *sources of the Rio Negro and the Uaupes*, and the culminant points of which are not probably from 100 to 120 toises high *, appear to extend towards the south to the basin of Rio Yupura, where rocky ridges form the cataracts of the Rio de los Engaños and the Salto Grande de Yupura (south lat. 0° 40′ to north lat. 0° 28′), and the basin of the Upper Guaviare towards the west. We find in the course of this river, from 60 to 70 leagues west of San Fernando del Atabapo, two walls of rocks that bound the *strait* (nearly 3° 10′ nor. lat. and 73¼′ long.) where the excursion of father Maniella finishes. That missionary told me, that in going up the Guaviare, he perceived near the strait (Angostura), a chain of mountains bounding the horizon on the south. It is not known whether those mountains traverse the Guaviare more to the west, and join the *counter-forts* which advance from the eastern Cordillera of New Grenada, between the Rio Umadea and the Rio Ariari, towards the savannahs of San Juan de los Llanos. I doubt much of this communication; if it had taken place, the plains of the Lower Oroonoko would communicate with those of the Amazon only by a very

* Vol. v, p. 332.

narrow land-strait, on the east of the mountainous country which surrounds the source of the Rio Negro; but it is more probable that this mountainous country (a small system of mountains, geognostically dependent on the Sierra Parime), forms something of an island in the Llanos of Guaviare and Yupura. Father Pugnet, guardian of the convent of St. Francis at Popayan, assured me, that when he went from the missions settled on the Rio Caguan to Aramo, a village situated on the Rio Guayavero, he found only savannahs destitute of trees *, extending as far as the eye could reach. The chain of mountains placed by several modern geographers † no doubt to adorn their maps, between the Meta and the Vichada, and which appears to link the Andes of New Grenada with the Sierra Parime, is altogether imaginary.

We have now examined the prolongation of the Sierra Parime on the west, towards the source of the Rio Negro: it remains for us to follow the same groupe in its eastern direction. The mountains of the Upper Oroonoko, east-

* What forest do the maps place in those countries (*Selva Grande* or *El Ayrico*)? The whole territory between the Upper Oroonoko and the missions of Caqueta is so unknown, that the positions of San Juan de los Llanos, Caguan, Aramo, and the confluence of the Rio Fragua with the Yupura or Caqueta, may be more than half a degree false in latitude.

† For instance, the great map of *South America*, by Arrowsmith.

ward of the Raudal des Guaharibos (nor. lat. 1° 15′ long. 67° 38′), join the *chain of Pacaraina* (Pacarahina, Pacaraymo, Baracayna), which divides the waters of the Carony and the Rio Branco, and of which the micaceous schistus, resplendent in their silvery lustre, became so important in the fable of the Dorado of Ralegh*. The part of that chain containing the sources of the Oroonoko has not yet been explored; but its prolongation more to the east, between the meridian of the military post of Guirior and the Rupunuri, a tributary stream of the Essequibo, is known to me † by the tra-

* Vol. v, p. 797, 798, 841, 857.

† The following is a list of the unpublished materials on which I found my description of the eastern part of the Sierra Parime: 1° Journal of Nicolas Hortsman (1740) found among d'Anville's papers (Vol. v, p. 594, 791), and communicated by his heirs. 2° Written notes (1778) dictated by Santos, when he passed from the missions of Carony to the plains of Rio Branco, crossing the chain of Pacaraina, which he calls Pacaraymo (Vol. v, p. 572, 839, 840). This manuscript, and the following, are preserved in the archives of Nueva Guayana, whence I took copies. 3° Journal of Don Nicolas Rodriguez, the friend of Santos, from Barcelonetta to the confluence of the Rio Mao (Mahu), and the Rio Branco, I traced a map on the very accurate indications of *rhumbs* and distances contained in this valuable manuscript. 4° Two very detailed maps of the captain of the frigate, and the astronomical geographer of the Portugueze commission of the boundaries, Don Antonio Pires de Sylva Pontes Leme, and the captain of engineers, Don Ricardo Franco d'Almeida de

vels of two Spaniards, Don Antonio Santos, and Nicolas Rodriguez, and also by the geodesic labors of the Portugueze Pontes and Almeida. There are two portages little frequented, between the Rio Branco and the Rio Essequibo (the portages of Sarauru and the lake Amucu), on the south of the chain of Pacaraina; they facilitate the *road by land* that leads from the Villa of the Rio Negro to Dutch Guyana *. The portage, on the contrary, between the basin

Serra (1787 and 1804). These manuscript maps, containing the whole detail of the trigonometric survey of the windings of the rivers, were obligingly communicated to M. Lapie and myself, by the Count of Linhares. It may be affirmed, that the course of few rivers in Europe has been marked by more minute operations than that of the Rio Branco, the Uraricuera, the Yacutu, and the Maho; and we may regret that in the state of barbarism in which the geography of the vast countries of Spanish and Portugueze America yet are, a predilection for such rigorous precision has prevailed respecting a wild and almost uninhabited region. 5° Notes of the voyage made by Francisco Jose Rodriguez Barata, Lieutenant Colonel of the first regiment of the line at Para, when ensign, by the Rio Branco, the Tacutu, and the Sarauru, to Rio Rupunuri and Surinam, in crossing (1793) the portage, or isthmus that separates on the south of Cerro Conucumu, the basins of the Rio Branco and the Essequibo (Vol. v, p. 480). I owe this information to the kindness of M. Brito, ambassador of Portugal at the court of France.

* The portage of the lake Amucu (Amacu), between the Caño Pirara, a tributary stream of the Rio Mahu and the Caño Tavaricuru or Tauricuru, is ten leagues north of the portage of Sarauru (Vol. v, p. 480).

of the Rio Branco, and that of the Carony, crosses the summit of the chain of Pacaraina. On the northern slope of this chain rises the Anocapra (Anuca-para? Nocaprai), a tributary stream of the Paraguamusi or Paravamusi; and on the southern slope, the Araicuque, which, with the Uraricapara, forms the famous *Valley of Inundations* *, above the destroyed mission of Santa Rosa (lat. 3° 46′, long. 65° 10′). The principal Cordillera, which appears of little breadth, stretches on a length of 80 leagues, from the portage of Anocapra (long. 65° 35′) to the left bank of the Rupunuri (long. 61° 50′), following the parallels of 4° 4′ and 4° 12′.

* Vol. v, p. 791. The Rio Uraricapara throws itself into the Uraricuera, called *Curaricara* in the manuscript of Rodriguez, and which may be considered as the western branch of the Rio Branco, while the eastern branch is the Tacutu, which receives the Mahu. The two branches join near the fort of San Joaquim of the Rio Branco. The Spaniards of Carony began to pass the chain of Pacaraina, and fix themselves on the Portugueze territory, in the years 1770 and 1773. They established successively the missions of Santa Rosa, San Juan Baptista de Cayacaya (Cadacada) and San Antonio (Caulin, p. 60); but those villages, or rather assemblages of huts, were destroyed by the Portugueze. Wars are unhappily but too frequent in this part of America, between the neighbouring missions of two rival nations. The map of Pontes marks at the junction of the Paraguamusi and the Rio Paragua (a tributary of the Carony), the village of San Vicente, lat. 4° 25′; the point where the Spanish military post of Guirior is placed.

We there distinguish, from west to east, the mountains of Pacaraina, Tipique, Tauyana, where rises the Rio Parime (a tributary stream of the Uraricuera), Tubachi, Cristaux (lat. 3° 56′, long. 62° 52′), and Canopiri. The Spanish traveller, Rodriguez, marks the eastern part of the chain by the name of *Quimiropaca*; but as the geognostic description of a country cannot make any progress without adopting general names, I continue to give the name of Pacaraina to the whole of this Cordillera, which links the mountains of the Oroonoko, to those of the interior of the Dutch and French Guyanas, and which Ralegh and Keymis had made known in Europe at the end of the 16th century. This chain is broken by the Rupunuri and the Essequibo, so that one of their tributary streams, the Tavaricuru, takes its rise on the southern declivity, and the other, the Sibarona, on the northern. In approaching the Essequibo, the mountains are more developed towards the south-east, and extend beyond the 2½° of north latitude. From this *eastern branch* * of the

* The culminant points of this eastern branch, are from S.E. to N.W.; the Sierras of Cumucumu, Xirivi, Yaviarna, Paranambo, Uanarari, and Puipe. I believe that the groupe of the mountains of Cumucumu (*Cum-Ucuamu*) in the map of Pontes, taken on the spot, is the *Cerro del Dorado* or *Cerro Ucucuamu* of the journal of Santos, and the *Acucuamo* of Caulin (*Corografica*, p. 176) between the Mahu and the Ru-

chain of Pacaraina the Rio Rupunuri rises near the Cerro Uassari. On the right bank of the Rio Branco, in a still more southern latitude (between 1° and 2° north) is a mountainous territory in which the Caritamini, the Padaviri, the Cababuri (Cavaburis) and the Pacimoni take their source, from east to west. This *western branch* of the mountains of Pacaraina separates the basin of Rio Branco from that of the Upper Oroonoko, of which the sources are probably not found on the east of the meridian of 66° 15′: it is linked with the mountains of Unturan and Yumariquin, lying S.E. of the mission of Esmeralda*. From the whole of these

punuri. The Isle Ip-*Amucena*, which Santos places in the middle of the Laguna Parime, recalls the name of lake *Amuca* (Amucena, Amacu), of which the existence, already announced by the surgeon Hortsmann de Hildesheim, has been certified by the most recent travels. (Vol. v, p. 791, 799.)

* The Indians who inhabit the banks of the Rio Branco, told M. Pontes that the Rio Mocajahi or Cahuana, which flows into the Rio Branco, at 2° 26′ of latitude, and which the Portugueze soldiers ascended in canoes during twenty days, over innumerable rapids and cataracts, communicates with the Cababury, which is at once a tributary stream of the Rio Negro and the Cassiquiare, (*See* above, Vol. v, p. 377, 418.) If this notion be correct, our maps prolong the course of the Padaviri much too far towards the north. It furnishes, according to the author of the *Corographia brasiliensis* (Vol. ii, p. 349), a portage to the Umavaca (no doubt the Macava, a tributary stream of the Upper Oroonoko). I am surprised at the detail

considerations it results, that while on the west of the Cassiquiare, between that river, the Atabapo, and the Rio Negro, we find only vast plains, in which rise some monticules and insulated rocks; real counter-forts stretch on the east of the Cassiquiare, from N.W. to S.E. and form a continued mountainous territory as far as the 2° of north latitude. The basin only, or rather the transversal valley of Rio Branco, forms a kind of gulph, a succession of plains

given in Arrowsmith's map, of the sources of the Padaviri, placed in 3° latitude, while in the manuscript maps of Pontes these sources are marked at 1½°. Heretofore the Daraha, the Padaviri, and the Uaraca, were supposed to join the Rio Branco, having three distinct mouths, and forming a delta of tributary streams. (*See Surville's map*, which accompanies the Corography of Caulin). The great inundations of Seriveni and Caritamini (lat. 1°—2° north) have no doubt given rise to the fable of lake Mauvatu, on the map of the Amazon traced by M. Requena, first commissary of the boundaries in the service of the King of Spain. These inundations, and the uniform assertion of the Indians, that the Rio Mocajahi communicates with the Cababury, may also have contributed to the hypothesis of the imaginary lake which Surville places west of the Rio Branco, and which he links at the same time to that river and the Oroonoko (Vol. v, p. 851). I shall here observe, that the lake Amuca of Hortsmann, and the two upper branches of the Rio Branco, the Uraricuera and the Mahu, which is the classical country of *Dorado of Ralegh*, are found, according to the astronomical observations of Portugueze travellers, between the parallels 3° and 4°, while Surville's map enlarged that space from 4° to the equator.

and savannahs (*campos*) several of which penetrate into the mountainous land, from south to north, between the eastern and western branches of the chain of Pacaraina, to the distance of 8 leagues north of the parallel of San Joaquin *.

We have just examined the southern part of the vast *system of the mountains of Parime*, between the 2° and 4° of latitude, and between the meridians of the sources of the Oroonoko and the Essequibo. The developement of this system of mountains towards the north, between the chain of Pacaraina and the Rio Cuyuni, and between the meridians 66° and 61¼°, is still much more unknown. The only road frequented by white men is that of the river Paragua, which receives the Paraguamusi, near the Guirior. We find indeed, in the journal of Nicolas Rodriguez, that he was constantly obliged to have his canoe carried by men (*arrastrando*) by the cataracts which intercept the navigation †; but we must not forget a

* We find savannahs between the Mayari and the Tacutu; but east and west of those rivers, between the Tacutu and the Rupunuri, the country is full of mountains. In considering the whole chain of Pacaraina, we observe that the eastern groupe, that of Cerro Cumucumu, is much loftier than the western, which contains the sources of the Caritamini.

† In ascending from Barcelonetta to the portage between Anocapra (no doubt *Anoca-para, water of Anoca*), and Araicuque, across the Sierra Pacaraina, we find along the banks

circumstance, of which my own experience furnished me with frequent proofs,—that the cataracts in this part of South America are often caused only by ridges of rocks which do not form real mountains. Rodriguez names but two between Barcelonetta and the mission of San Jose; while the missionaries place more to the east, in 6° latitude, between the Rio Carony and the Cuyuni *: the Serranias of Usupama and Rinocote. The latter crosses the Mazaruni, and forms 39 cataracts in the Essequibo †, from the military post of Arinda (lat. 5°30′) to the mouth of Rupunuri.

With respect to the continuation of the system of the mountains of Parime, south-east of the meridian of the Essequibo, the materials are entirely wanting for tracing it with

of the Paragua and the Paraguamusi, from north to south, the confluence of the Carony and the Rio Paragua; the mouth of the Rio Hore; the Cerro Paragua, near the western bank of Paragua; Raudals of Orayma, Guayquirima and Carapo; the Cerro del Gallo; the village of San Jose; the mouth of Caño de Espuma; the Raudals of Guayguari and Para; the great Raudal of Mayza; the Boca of Caño Icapra; the Boca of Paraguamusi, and the Raudals of Anocapra. (*Razon de lo que ha sucedido a Don Nicolas Rodriguez durante su navegacion en el Rio Paragua y en las Missiones altas de los Reverendos Padres Capuchinos de Carony, fol.* 7-15 *manuscript*).

* Map which accompanies father Caulin's work.

† *Van Buchenræder*, Map of the Colony of Essequibo, 1798.

precision. The whole interior of the Dutch, French, and Portugueze Guyanas, is a *terra incognita*; and the astronomical geography of those countries has scarcely made any progress during thirty years*. If the American limits recently fixed † between France and Portugal, should one day cease to belong to the illusions of diplomacy, and acquire reality, in being traced on the territory by means of astronomi-

* It is certain that M. Le Blond, correspondent of the Academy of Sciences, in going up the river Oyapock, notwithstanding all his zeal, only reached a little beyond the mouth of the Suacari. The sources of the Araguari (Araouari), the Oyapock, the Camopi, and the Tamouri (tributaries of the Oyapock), and the Araouna (tributary of the Maroni), are very near each other, in 2° 30′ latitude, and 35° 10′ longitude. A voyage of discovery should be made from this point of French Guyana, towards the confluence of the Rio Branco with the Rio Negro, in the direction S. 75° W., on a distance of 220 leagues. The borders of French Guyana lie between Cape Orange and the mouth of the Maroni, S. E. and N. W. Now, in a perpendicular direction to the shore of Cayenne, none of the *pretended great expeditions of the interior* have led white men beyond Mount Tripoupou and the post of the Roukouyenes Indians, at the distance of more than 70 leagues! The communications opened by land between the Capitania of Rio Negro and the shore of Guyana have been directed solely along the Rio Essequibo, on account of the facility furnished by the proximity of its tributary streams to those of the Rio Branco.

† In consequence of the treaty of Vienna. *See* above, Vol. v, p. 842.

cal observations, (as was projected in 1817,) this undertaking would lead geographical engineers to that unknown region which, at 3½° west of Cayenne, divides the waters between the coast of Guyana and the Amazon. Till that period, which the political state of Brazil seems to retard, the geognostic table of the groupe of Parime can only be completed by scattered notions collected in the Portugueze and Dutch colonies. In going from the Uassari mountains (lat. 2° 25′, long. 61° 50′) which form a part of the eastern branch of the Cordillera of Pacaraina, we find towards the east, a chain of mountains called by the missionaries *Acaray* and *Tumucuraque* *. Those two names wander on our maps between 0½° and 3° of

* The Sierra *Tumucuraque* (Tumumucuraque of Caulin, Tumucucuraque of Arrowsmith) appeared for the first time on the map of La Cruz; and, as the name is there twice placed with a difference of 3° of latitude, this double nomination has been religiously repeated on the maps of Surville, Buache, &c. The geographer Sanson, who, in his *Course of the river of the Amazons, traced from the narrative of father Acuna* (1680), had the merit, in suppressing the lake Parime and the Sierra Wacarima (Pacarahina) which had till then been figured in the direction of a meridian, to have first traced with some precision, a chain of mountains stretching parallel to the equator, between the northern sources of the Essequibo, Maroni, and Viapoco (Oyapock), and the southern sources of the Urixamina (R. de Trombetas), of Curupatuba, and of the Ginipape or Rio Paru.

north latitude. Ralegh first made known * in 1596, the system of the mountains of Parime, between the sources of the Rio Carony and the Essequibo, by the name of Wacarima (Pacarima); and the jesuits Acuna and Artedia furnished, in 1639, the first precise notions of that part of this system which extends from the meridian of Essequibo to that of Oyapock †. There they place the mountains of Yguaracuru and Paraguaxo, the former of which gives birth to a gold river *(Rio de oro)*, a tributary stream of the Curupatuba ‡; and according to the assertion of the natives, subterraneous noises are sometimes heard from the latter. The ridge of this chain of mountains, which may be followed in a direction S. 85° E., from the peak Duida, near the Esmeralda (lat. 3° 19′), to the

* Vol. v, p. 797, &c.

† Vol. v, p. 865.

‡ When we know that in Tamanac gold is called *caricuri*; in Carib, *caricura*; in Peruvian, *cori (curi)*, we easily recognize in the names of the mountains and rivers (Yguara-curu, Cura-patuba), which we have just marked, the indication of an auriferous soil. Such is the analogy of the *imported roots* in the American tongues, which otherwise differ altogether from each other, that 300 leagues west of the mountain Ygaracuru, on the banks of the Caqueta, Pedro de Ursua heard of the province of *Caricuri*, rich in gold washings. (Vol. v, p. 823). The Curupatuba falls into the Amazon near the Villa of Monte Alegre, N. E. of the mouth of the Rio Topayos.

rapids of the Rio Manaye, near cape Nord (lat. 1° 50′), divides, in the parallel 2°, the northern sources of the Essequibo, the Maroni, and the Oyapock, from the southern sources of the Rio Trombetas, Curupatuba, and Paru. The most southern counter-forts of this chain draw nearer the Amazon, at the distance of fifteen leagues. These are the first heights that we perceived after having left Xeberos and the mouth of the Huallaga*. They are constantly seen in navigating from the mouth of the Rio Topayo towards that of Paru, from the town of Santarem to Almeirim. The peak Tripoupou † is placed nearly in the meridian of the former of those towns, and is celebrated among the Indians of Upper Maroni. More to the east, at Melgaço, the Serras do Velho and do Paru ‡ are still distinguished in the horizon. The real limits of this series of sources of the Rio Trombetas

* Vol. vi, p. 431. *See* also La Condamine's, *Voyage to the Amazon*, p. 143. The distance at which we see those counter-forts gives them 200 toises of absolute height. They are, however only, says Condamine, the anterior hills of a long chain of mountains extending from west to east, and of which the summits form the points of partition of the waters; the northern waters flow towards the coast of Cayenne and Surinam, and the southern towards the Amazon.

† Lat, 2° 10′, long. 1° 36′ west of the meridian of Cayenne, according to the map of Guyana, published at the *Depôt of the Marine*, 1817.

‡ *Corographia Brazil*, Vol. ii, p. 297.

are better known towards the south than the north, where a mountainous country appears to advance in Dutch and French Guyana, as far as from 20 to 25 leagues of the coast. The numerous cataracts of the rivers of Surinam, Maroni, and Oyapock, prove the extent and the prolongation of rocky ridges; but nothing hitherto indicates that there exists in those regions (as sometimes has been hastily announced), *continued plains*, or table-lands some hundred toises high, fitted for the cultivation of the plants of the temperate zone.

I have just collected into one geognostic table all the materials I possess on the *system of the mountains of Parime*. Its extent surpasses nineteen times that of the whole of Switzerland; and even considering the mountainous groupe of the sources of the Rio Negro and the Xie as independent or insulated amidst the plains, we still find the Sierra Parime (between Maypures and the sources of the Oyapock) to be 340 leagues in length, and its greatest breadth (the rocks of Imataca, near the delta of the Oroonoko, at the sources of the Rio Paru) 140 leagues. In the groupe of the Parime, as well as in the groupe of the mountains of central Asia, between the Himalaya and the Altai, the partial chains are often interrupted, and present no constant parallelism. Towards the south-west however, (between the strait of

Baraguan, the mouth of the Rio Zama, and the Esmeralda) the line of the mountains is generally in the direction of N. 70° W. Such is also the position of a distant coast, that of the Portugueze, French, Dutch, and English Guyanas, from Cape North to the mouth of the Oroonoko; such is the mean direction of the course of the Rio Negro and Yupura. I wish to fix the attention of geognosts on the angles formed by the partial chains, in different regions of America, with the meridians; because on less extended surfaces, for instance in Germany *, we find also this singular co-existence of groupes of neighbouring mountains which follow laws of direction altogether different, although we observe in every groupe insulately, the greatest uniformity in the line of chains.

The soil on which the mountains of Parime rise, is slightly convex †. I found by barometric measures, that between 3° and 4° of north latitude, the plains are elevated from 160 to 180 toises above the level of the sea. This height will appear considerable if we reflect that at the foot of the Andes of Peru, at Tomependa, 900 leagues distant from the coast of

* *Leopold von Buch, uber Dolomit, zweite Abhoudl.*, 1823, p. 54.

† *Recueil d'Obs. astronomiques*, Tom. ii, p. 293, *Personal Narrative*, Vol. v, p. 252, 550.

the Atlantic Ocean, the Llanos or plains of the Amazon rise only 194 toises*. What most characterizes the groupe of the mountains of Parime are the rocks of granite and gneiss-granite, the total absence of calcareous secondary formations, and the shelves of bare rock (the *Tsy* of the Chinese deserts), which fill on the surface, immense spaces in the savannahs †.

ε. Groupe of the Mountains of Brazil. This groupe has hitherto been figured on the maps in as singular a manner as the mountains of the Iberian Peninsula, Asia Minor and Persia. The temperate table-lands and real chains of 300 to 500 toises high, have been confounded with countries excessively hot, and of which the undulating surface presents only ranges of hills variously grouped. The excellent barometric measures of Baron Eschwege, director general of the gold mines in the province of Minas Geraes, and the observations made in different parts of Brazil, by the prince of Neuwied, MM. Auguste de Saint Hilaire, Olfers, Spix, Pohl, and Martius, have recently thrown great light on the orography of Portugueze America. The mountainous region of Brazil, of which the mean height rises at least

* Vol. vi, p. 395.

† Vol. iv, p. 552; and v, p. 26.

to 400 toises, is comprehended within very narrow limits, nearly between 18° and 28° south latitude; it does not appear to extend, between the provinces of Goyaz and Mato-Grosso, beyond 53° of longitude, west of the meridian of Paris.

When we regard in one view the eastern configuration of both Americas, we perceive that the coast of Brazil and Guyana, from Cape Saint Roque to the mouth of the Oroonoko (stretching S. E. to N. W.), corresponds with that of Labrador, as the coast from Cape Saint Roque to the Rio de la Plata corresponds with that of the United States (stretching from S. W. to N. E.). The chain of the Alleghanies is opposite to the latter coast, as the principal Cordilleras of Brazil are nearly parallel to the shore of the provinces of Porto Seguro, Rio Janeiro, and Rio Grande. The Alleghanies, generally composed of grauwakke and transition rocks, are a little loftier than the almost primitive mountains (of granite, gneiss, and micaslate,) of the Brazilian groupe; they are also of a far more simple structure, their chains lying nearer each other, and preserving, as in the Jura, a more constant parallelism.

If, instead of comparing those parts of the New Continent situated north and south of the equator, we confine ourselves to South America, we find on the western and northern coasts in

their whole length, a continued chain near the shore (the Andes and the Cordillera of Venezuela), while the eastern coast presents masses of more or less lofty mountains only between the 12° and 30° of south latitude. In this space of 360 leagues in length, the system of the mountains of Brazil corresponds geognostically in its form and position, with the Andes of Chili and Peru. Its most considerable portion lies between the parallels 15° and 22°, opposite the Andes of Potosi and la Paz, but its mean height is five toises less, and cannot even be compared with that of the mountains of Parime, Jura, and Auvergne. The principal direction of the Brazilian chains, where they attain the height of four to five hundred toises, is from south to north, and from south-south-west to north-north-east; but, between 13° and 19° the chains are considerably enlarged, and at the same time lowered towards the west. The ridges and ranges of hills seem to advance beyond the land straits which separate the sources of the Rio Araguay, Parana, Topayos, Paraguay, Guapore, and Aguapehy, in 63° of longitude. The western widening of the Brazilian groupe, or rather the undulations of the soil in the Campos Parecis, corresponding with the *counterforts* of Santa Cruz, of Sierra, and Beni*,

* Vol. vi, p. 421, 431.

which the Andes send towards the east, it was heretofore concluded that the system of the mountains of Brazil was linked with that of the Andes of Upper Peru. I partook myself of this error in my first geognostic labours.

A coast chain *(Serra do Mar)* extends nearly parallel with the coast, north-east of Rio Janeiro, lowering considerably towards Rio Doce, and losing itself almost entirely near Bahia (lat. 12° 58′). According to Mr. Eschwege *, some small ridges reach Cape Saint Roque (lat. 5° 12′). South-east of Rio Janeiro, the *Serra do Mar* follows the coast behind the Isle Saint Catherine as far as Torres (lat. 29° 20′); it there turns towards the west and forms an elbow stretching by the Campos of Vacaria, towards the banks of the Jacuy †.

Another chain lies west of the shore chain of Brazil, the most lofty and considerable of all, that of Villarica ‡, which Mr. Eschwege marks by

* *Geognostiches Gemälde von Brasilien*, 1822, p. 5. The limestone of Bahia abounds in lignites. *Id.* p. 9.

† *Manuscript notes of M. Auguste de Saint Hilaire.* I owe to that great naturalist, whose extended views comprehended all that interests physical geography, some important rectifications of my sketch on the Brazilian system of mountains.

‡ Height of the town above the level of the sea, 630 toises. This height proves that Villarica is placed in the chain itself *(Sarro do Espinhaço)*, for the table-land of *Mi-*

the name of *Serra do Espinhaço,* and considers as the principal part of the whole structure of the mountains of Brazil. This Cordillera loses itself towards the north*, between Minas Novas and the southern extremity of the Capitania of Bahia, in 16° of latitude. It there remains more than 60 leagues removed from the coast of Porto Seguro; but towards the south, between the parallels of Rio Janeiro and Saint Paul (lat. 22° — 23°), in the knot of the mountains of Serra da Mantiqueira, it draws so near the Cordillera of the shore *(Serra do Mar)* that they are almost confounded together. In the same manner the *Serra do Espinhaço* follows constantly the direction of a meridian, towards the north; while towards the south, it runs south-east, and terminates towards 25° of latitude. The chain reaches its highest elevation between 18° and 21°; and there, the counterforts and table lands at its back are of suffici-

nas Geraes, or the counterforts that unite the *Serra do Espinhaço* to that of Goyaz or *dos Vertentes,* are generally only 300 toises of absolute height. (*Eschwege, Journal von Brasilien,* 1818, Vol. ii, p. 213.)

* The rocky ridges that form the cataract of Paulo Affonso, in the Rio San Francisco, are supposed to belong to the northern prolongation of the *Serra do Espinhaço,* as a series of heights in the province of Seara, or fetid calcareous rocks containing a quantity of petrified fish, belong to the *Serra dos Vertentes.*

ent extent to furnish lands for cultivation where temperate climates prevail by degrees, that may be compared with the delicious climates of Xalapa, Guaduas, Caraccas, and Caripe. This advantage, which depends at once on the widening of the mass of the chain, and of its counterforts, is no where found in the same degree, on the east of the Andes, not even in chains of a more considerable absolute height, for instance in those of Venezuela and the Oroonoko. The culminant points of the *Serra do Espinhaço,* in the Capitania of Minas Geraes, are the Itambe (932 t.), the Serra da Piedade, near Sabara (910 t.), the Itacolumi, properly Itacunumi (900 t.), the Pico of Itabira (816 t.), the Serras of Caraça, Ibitipoca, and Papagayo. M. Auguste de Saint Hilaire felt a piercing cold in the month of November, therefore in summer, in the whole Cordillera of Lapa, from the Villa do Principe to the Morro of Gaspar Suares *.

We have just recognized two chains of mountains nearly parallel, but of which the most extensive (that of the shore) is the least lofty. The capital of Brazil is situated at the point where the two chains draw nearest, and are linked together on the east of the Serra de

* Sketch of a voyage to Brazil. p. 5. *Eschwege*, p. 5, 29-30, and above, Vol. v, p. 858; Vol. vi, p. 402.

Mantiqueira, if not by a transversal ridge, at least by a mountainous territory. According to ancient systematic ideas on the rising of mountains, in proportion as we advance into a country, it was supposed that a *central Cordillera* existed in the Capitania of Mato Grosso, much loftier than that of Villarica or *do Espinhaço;* but we now know (and this is confirmed by climateric circumstances) that there exists no continued chain, properly speaking, to the westward of Rio San Francisco, on the frontiers of Minas Geraes and Goyaz. We find only a groupe of mountains of which the culminant points are the Serras da Canastra (south-west of Paracatu) and da Marcella (lat. 18½° and 19·10°), and further north, the Pyrineos stretching from east to west (lat. 16° 10′ between Villaboa and Mejaponte). Mr. Eschwege has named the groupe of mountains of Goyaz the *Serra dos Vertentes*, because it divides the waters between the southern tributary streams of the Rio Grande or Parana, and the northern tributary streams of Rio Tucantines. It runs towards the south beyond the Rio Grande (Parana), and approaches in 23° latitude, by the *Serra do Franca*, the *Espinhaço*. It attains only 300 to 400 toises of height, with the exception of some summits N. W. of Paracatu, and is consequently much lower than the chain of Villarica.

Further on, west of the meridian of Villaboa, there are only ridges and a series of monticules which, on a length of 12°, form the *threshold* or division of water (lat. 13°—17°), between the Aragnay and the Paranaiba (a tributary stream of the Parana), between the Rio Topayos, and the Paraguay, between the Guapore and the Aguapehy. The Serra of S. Martha (long. 15½°) is somewhat lofty, but geographers, or rather the drawers of maps, have preserved the habit of singularly exaggerating the height of the *Serras* or *Campos Parecis*, on the north of the towns of Cuyaba and Villabella (lat. 13°—14°, long. 58°—62°). These Campos, which have taken their name from that of a tribe of wild Indians *, are vast barren table-lands, entirely destitute of vegetation, and in which the sources † of the tributary streams of three

* *Patriota*, 1813, No. 1, p. 48; No. 6, p. 40, 51. The western part of these *Campos* is called *Urucumanacua*, between the Secury and the Camarare, two tributary streams of the Rio Topayos.

† The neighbouring tributary streams of the Topayos are the Jurucna, and the Camarare; those of Madeira, the Alegre, the Guapore, and the Sarare; those of Paraguay, the Aguapehy, the Jauru, and the Sipotobu. Villabella, of which the position may one day become important for the inland trade between the Amazon and the Rio de la Plata, is placed (lat. 15° 0′, long. 62° 18′) on the right bank of the Guapore or Itenes, a little above the confluence of the Sararé. On the south of Santa Barbara, the Aguapehy (a tributary stream

great rivers, the Topayos, the Madeira, and the Paraguay, take their rise. The learned author of the statistical description of the Capitania of Mato Grosso, M. Almeida Serra, calls * *Atlas Serranias* (high mountains), those of the banks of the Aguapehy; but we must not forget, that in a flat country, mountains of 500 feet high appear lofty; above all, if (like the rocks of Baraguan and the Morros of San Juan †) the mass is inconsiderable. The most recent manuscript maps of Brazil place, 1st. the Serra da

of the Paraguay and the Rio de la Plata), approaches so near the Rio Alegre, (a tributary of the Guapore and the Amazon), that the portage is only 5322 *braças* long. A canal was there attempted to be traced during the ministry of Count de Barca (*Eschwege, Gemälde*, p. 7); a circumstance that would not prove alone, the absence of chains of mountains, for openings and transversal valleys are found in the greatest Cordilleras. A degree below the confluence of the Paraguay and the Jauru, which receives the Aguapehy, a marshy soil begins. It extends as far as Albuquerque, and its inundations (lat. 17°—19°) have given rise to the fable of the Laguna de Xarayes, as the inundations of the Rio Parime (Rio Branco), gave birth to the fable of the Laguna Parime (Mar del Doradoor Rupunuwini). See *Patriota*, 1813, No. 5, p. 33, and *manuscript Map of Brazil, taken from 76 particular maps, at the depôt of Maps of Rio Janeiro, by Silvan Pontes Leme*, 1804.

* Geographical and political view of the Capitania of Mato Grosso (1791), by the serjeant-major of engineers, Ricardo Francisco de Almeida Serra.

† In the Lower Oroonoko and in the Llanos of Venezuela. *See* above, Vol. iv, p. 279, 503.

Melguera or *dos Limites*, on the west of Villabella, between the Guapore and the Baures; 2d. the Serra Baliza, between the Buenos and the Alegre; and 3d. the Cordillera of San Fernando, between the ancient missions of San Juan Bauptista and San Jago (lat. 16°—20°) advancing in the province of Chiquitos to 64½° of longitude, and approaching within 40 leagues distance of the counterfort of the Andes of Santa Cruz of Sierra; but these labours, although executed at the hydrographic Depôt of Rio Janeiro, do not merit much confidence in the western regions of Brazil, that *terra incognita*, which extends from Cochabamba to Villabella. The form of the insulated mountains in the plains of Chiquitos, the lakes between the missions of San Rafael, San Jose, and San Juan Bauptista, copied from d'Anville and La Cruz, are become *stereotypes* on every map for eighty years past; and it is certain that a landstrait, a plain covered with some hills, in 62° and 66° of longitude, unites the great basins of La Plata and the Amazon. M. Eschwege obtained precise information from some Spanish planters, who came from Cochabamba to Villabella, on the continuity of those basins or savannahs.

According to his measures and geognostic observations, the high summits of the *Serra do Mar* (the coast chain) scarcely attain 660

toises; those of the *Serra do Espinhaço* (chain of Villarica), 950 toises; those of *Serra do los Vertentes* (groupe of Canastra and the Brazilian Pyrenees) 450 toises. Further west, the surface of the soil seems to present but slight undulations; but no measure of height has been made beyond the meridian of Villaboa. Considering the system of the mountains of Brazil in their real limits (as we have indicated above), we find, except some conglomerates, the same absence of secondary formations with which we were struck in the system of the mountains of the Oroonoko (groupe of Parimé). These secondary formations, which rise to considerable heights in the Cordillera of Venezuela and Cumana, belong to the low regions only of Brazil *.

B. *Plains (Llanos) or Basins.*

We have now successively examined, in that part of South America situated on the east of the Andes, *three systems of mountains*, those of the shore of Venezuela, Parime, and Brazil; we have seen that this mountainous region, which equals the Cordillera of the Andes, not in mass, but in *area* and horizontal section of surface, is three times less elevated, much poorer in precious metals adhering to the rock,

* *Eschwege*, p. 15.

destitute of recent traces of volcanic fire, and, with the exception of the coast of Venezuela, little exposed to the violence of earthquakes. The mean height of the three systems diminishes from north to south, from 750 to 400 toises *; those of the culminant points (*maxima* of the height of each groupe), from 1350 to 1000 or 900 toises. It results from these observations, that the loftiest chain, with the exception of the small insulated system of the Sierra Nevada of Santa Marta †, is the Cordillera of the shore of Venezuela, which is itself but a continuation of the Andes. In taking a view of the north, we find in central America (lat. 12°—30°), and north America (lat. 30—70°), on the east of the Andes of Guatimala, Mexico, and Upper Louisiana, the same regular lowering which struck us towards the south. In this vast extent of land from the Cordillera of Venezuela to the polar circle, eastern America presents two distinct systems, the groupe of the mountains of the West Indies, of which the eastern part is volcanic, and the chain of the Alleghanies. The former of these systems, partly overwhelmed in the floods, may be compared with respect to its relative position and form, to the Sierra Parime; the latter to the chains of Brazil, run-

* See above, Vol. vi, p. 405.

† See above, Vol. vi, p. 481.

ning alike from S. W. to N. E. The culminant points of those two systems rise to 1138 and 1040 toises. Such are the elements of this curve, of which the convex summit is placed in the chain of the shore of Venezuela:

AMERICA, ON THE EAST OF THE ANDES.

SYSTEMS OF MOUNTAINS.	MAXIMA OF HEIGHTS.
Groupe of Brazil.....	Itacolumi ..... 900 t. (south lat. $20\frac{1}{2}°$).
Groupe of Parime.....	Duida..... 1300 (north lat. $3\frac{1}{4}°$).
Chain of the shore of Venezuela.....	Silla de Caraccas.... 1350 (north lat. $10\frac{1}{2}°$).
Groupe of the West Indies...	Blue Mountains..... 1138 (north lat. $18\frac{1}{5}°$).
Chain of the Alleghanies	Mount Washington. 1040 (north lat. $44\frac{1}{4}°$).

I have preferred indicating in this table the culminant points of each system, to the mean height of the line of elevation; the culminant points are the results of direct measures, while the mean height is an abstract idea somewhat vague, above all when there is only one groupe of mountains, as in Brazil, Parime, and the West Indies, and not a continued chain. Although

it cannot be doubted that among the five systems of mountains on the east of the Andes, and of which one only belongs to the southern hemisphere, the chain of the shore of Venezuela is the most elevated (having a culminant point of 1350 toises, and a mean height from the line of elevation of 750), we yet recognize with surprize, that the mountains of eastern America (whether continental or insulary), differ very inconsiderably in height above the level of the Ocean. *The five groupes are all nearly of a mean height of from five to seven hundred toises; and the culminant points (maxima of the lines of elevation), from one thousand to thirteen hundred toises.* That conformity of construction on an extent twice as great as Europe, appears to me a very remarkable phenomenon. No summit on the east of the Andes of Peru, Mexico, and Upper Louisiana, enters within the limit of perpetual snow *. It may be added, that with the exception of the Alleghanies, no snow falls sporadically in any of the eastern systems which

* Not even the *White Mountains* of the state of New Hampshire, to which Mount Washington belongs. Long before the accurate measurement of Captain Partridge, I had proved (in 1804), by the laws of the decrease of heat, that no summit of the *White Mountains* could attain the height assigned to them by M. Cutler, of 1600 toises. (*See* my Spanish memoir: *Ideas sobre el limite inferior de la nieve perpetua* in *l'Aurora ò Correo de la Havana*, No. 220, p. 142.)

we have just examined. From these considerations it results, and above all, from the comparison of the New Continent with those parts of the ancient which we know best, with Europe and Asia, that America thrown into the *aquatic hemisphere** of our planet, is still more remarkable by the continuity and extent of the depressions of its surface, than by the height and continuity of its longitudinal ridge. The mountains beyond and within the isthmus of

* The southern hemisphere, on account of the unequal distribution of seas and continents, has long been marked as an hemisphere eminently aquatic; but the same inequality is found when we consider the globe as divided not according to the equator but by meridians. The great masses of land are joined together between the meridian of 10° west, and 150° east of Paris, while the hemisphere eminently aquatic, begins on the west of the meridian of the coast of Greenland, and ends on the east of the meridian of the eastern coast of New Holland and the Kurile Isles. This unequal distribution of land and water has the greatest influence on the distribution of heat on the surface of the globe, on the inflexions of the isotherm lines, and the climateric phenomena in general. For the inhabitants of the centre of Europe the aquatic hemisphere may be called western, and the land hemisphere eastern; because in going to the west we reach the former sooner than the latter. It is the division according to meridians, which is intended in the text. Till the end of the 15th century, the western hemisphere was as much unknown to the nations of the eastern hemisphere, as one half of the lunar globe is to us at present, and will probably always remain.

Panama, but on the east of the Cordillera of the Andes, scarcely attain, on 600,000 square leagues, the height of the Scandinavian Alps, the Carpathes, Monts-Dores (in Auvergne), and the Jura. One system only, that of the Andes, unites in America on a long and narrow zone of 3000 leagues, all the summits which are more than 1400 toises high. In Europe, on the contrary, even considering, with too systematic views, the Alps and Pyrenees as one sole line of elevation, we still find summits far from this line or principal ridge, in the Sierra Nevada of Grenada, Sicily, Greece, the Appenines, perhaps also in Portugal, from 1500 to 1800 toises high*. The contrast between America and Europe, with respect to the distribution of the culminant points which attain 1300 to 1500 toises, is the more striking as the low eastern mountains of South America, of which the

* Culminant points; Mulhacan of Grenada, 1826 toises; Etna, according to Captain William Henry Smith, 1700 t. Monte Corno of the Appenines, 1489 t. If Mont Tomoros in Greece and the Serra Gaviarra of Portugal, enter, as is asserted, within the limit of perpetual snows (*Pouqueville*, Tom. ii, p. 242, and *Balbis, Essai statistique sur le Portugal*, Tom. i, p. 68, 98), those summits, according to their position in latitude, should attain 1400 to 1600 toises. Yet on the loftiest mountains of Greece, the Tomoros, the Olympus of Thessalia, the Polyanos of Dolopes, and Mount Parnassus, M. Pouqueville saw, in the month of August, snow preserved only in stripes, or in cavities sheltered from the rays of the sun.

maxima of the elevation is only from 1300 to 1400 toises, are placed on the side of a Cordillera of which the *mean height* exceeds 1800 toises, while the secondary system of the mountains of Europe rises to *maxima of elevation* of 1500 to 1800 toises, near a principal chain of 1200 toises at least of *mean height.*

MAXIMA OF THE LINE OF ELEVATION IN THE SAME PARALLELS.

Andes of Chili and Upper Peru. Knots of mountains of Porco and Cuzco, 2500 toises.

Andes of Popayan and Cundinamarca. Chain of Guacas, Quindiu, and Antioquia. More than 2800 t.

Insulated groupe of the snowy mountains of Santa Martha. It is believed to be 3000 toises high.

Volcanic Andes of Guatimala, and primitive Andes of Oaxaca, from 1700 to 1800 t.

Andes of New Mexico and Upper Louisiana (Rocky Mountains), and further west *Maritime Alps of New Albion,* 1600 to 1900 t.

Groupe of the Mountains of Brazil, a little lower than the Cevennes, 900 to 1000 toises.

Groupe of the Mountains of Parime, little lower than the Carpathes, 1300 t.

Chain of the shore of Venezuela, 80 t. lower than the Scandinavian Alps, 1350 toises.

Groupe of the West Indies, 170 toises higher than the mountains of Auvergne, 1140 t.

Chains of the Alleghanies, of 160 t. higher than the chains of Jura and the gates of Malabar, 1040 t.

This table * contains the whole system of mountains of the New Continent; namely: the Andes, the maritime Alps of California or New Albion, and the five groupes of the east. I shall subjoin to the facts I have just stated, an observation no less striking; in Europe, the *maxima* of secondary systems, which exceed 1500 toises, are found solely on the south of the Alps and Pyrenees, that is, on the south of the principal ridge of the continent. They are placed on the side where that ridge draws nearest the shore, and where the Mediterranean has not overwhelmed the land. On the north

* In order to justify the correctness of the comparisons furnished in this table, we shall mention the following heights: Mont Mezin (Cevennes) 1027 toises; the Puy de Sancy, vulgarly called the Puy de la Croix, summit of Mount Dores in Auvergne, 972 t.; the Reculet (Jura), according to the last survey of M. Roger, officer of engineers, 880 t.; Mount Taddiandamalla in the Gates of Malabar, according to the operations of Colonel Lambton, 887 t.; the White Mountains of New Hampshire, in the northern part of the Alleghanies, rise to 1040 t.; but towards the south, a few instances in Virginia, the Peaks of Otter (Blue Ridge), are considered as very lofty; according to Morse, they are 486 t.; according to Tanner, 667. The mean height of the *line of elevation* of the Alleghanies is nearly 450 t., consequently at least 200 t. less than the mean height of the Jura. The table to which this note refers, furnishes the comparisons only of the loftiest summits, the maxima of their ridges, which we must take care not to confound with their *mean height*.

of the Alps and Pyrenees, on the contrary, the most elevated secondary systems, the Carpathian and the Scandinavian mountains* do not attain 1300 toises of height. The depression of the line of elevation of the second order is consequently found in Europe as well as in America, on the side where the *principal ridge is farthest removed from the shore.* If we did not fear to subject great phenomena to too small a scale, we might compare the difference of the height of the Alps and the mountains of eastern America, with the difference of height observed between the Alps or the Pyrenees, and the mountains Dores, Jura, the Vosges, or the Schwarzwald.

We have just seen that the causes which heaved up the oxidated crust of the globe in ridges, or in groupes of mountains, have not acted very powerfully in the vast extent of country that stretches from the eastern part of the Andes, towards the ancient continent; that depression and that continuity of plains are geologic facts, so much the more remarkable, as they extend no where else on more different

* The Lomnitzer Spiz of the Carpathian, is, according to M. Wahlenberg, 1245 toises; the Sneehaetta, in the chain of Dovrefield in Norway (the highest summit of the whole ancient continent, on the north of the parallel of 55°), is 1270 toises above the level of the sea.

latitudes. The five systems of mountains of eastern America, of which we have indicated the limits, divide that part of the continent into an equal number of basins, of which only, that of the Caribbean sea has remained submerged. From north to south, from the polar circle towards the strait of Magellan, we see in succession:

a. THE BASIN OF THE MISSISSIPI AND OF CANADA. An able geologist, Mr. Edwin James, has shewn recently * that this basin is comprehended between the Andes of New Mexico, or the Upper Louisiana, and the chains of the Alleghanies which stretch towards the north in crossing the rapids of Quebec. It being quite as open towards the north as towards the south, it may be designated by the collective name of the basin of the Mississipi, the Missouri, the river Saint Lawrence, the great lakes of Canada, the Mackenzie river, the Saskatchawin, and the coast of Hudson's Bay. The tributary streams of the lakes and those of the Mississipi are not separated by a chain of mountains running from east to west, as traced on several maps; the line of partition of the waters is marked by a slight ridge, a rising of the two counter-

* *Long, Expedition,* Vol. i, p. 7; Vol. ii, p. 380, 428.

slopes in the plain*. No chain exists between the sources of the Missouri and the Assiniboni, which is a branch of the Red River and of Hudson's Bay. The surface of these plains, almost all in savannahs, between the polar sea and the gulph of Mexico, is more than 270,000 square marine leagues, nearly equal to the *area* of all Europe. On the north of the parallel of 42°, the general slope of the land runs towards the east; on the south of the parallel, it inclines towards the south. To form a precise idea how little abrupt are these slopes †, we must recollect that the level of Lake Superior is 100 toises; that of Lake Erie, 88 t.; and that of Lake Ontario, 36 t. above the level of the waters of the Ocean. The plains around Cincinnati (lat. 39° 6′), are scarcely, according to Mr. Drake, 80 t. of absolute height. To-

* *See* above, Vol. iv, p. 151.

† *Tanner, American Atlas*, 1823, p. 9. *Amos Eaton and Stephen van Rensselaer, Geolog. Survey of Erie Canal*, 1824, p. 151. In the United States, the slope of the Missouri is estimated from its confluence with the river Platte (lat. 41° 3′ 13″) as far as its mouth in the Mississipi, (lat. 38° 51′ 39″, long. 92° 22′ 55′) from 3 to 4 miles an hour, or 14½ inches of French feet by the English mile of 827 toises; the slope of the Mississipi, from its confluence with the Missouri to the sea, is estimated at 10½ inches. (*Long, Exped.* Vol. ii, Append. p. xxvi, xxviii; and above, *Per. Nar.* Vol. iv, p. 246.)

wards the west, between the Mounts Ozark and the foot of the Andes of Upper Louisiana (*Rocky Mountains*, lat. 35°—38°), the basin of the Mississipi is considerably raised in the vast desart described by Mr. Nuttal. It presents a series of small table-lands, succeeding each other by degrees, and of which the most westerly (the nearest the Rocky Mountains, between the Arkansas and the Padouca), rises more than 450 toises. Major Long measured a base to determine the position and the height of James Peak. In the great basin of the Mississipi, the line that separates the forests and the savannahs runs, not, as may be supposed, in the manner of a parallel, but like the Atlantic coast, and the Alleghany mountains themselves, from N.E. to S.W., from Pittsbourg towards Saint Louis, and the Red River of Natchitotches, so that the northern part only of the state of the Illinois is covered with gramina *. This line of demarcation is not only interesting for

* Manuscript Observations of Mr. Gallatin. Beyond, that is, on the west of the savannahs or fields of the Missouri, we again find forests at the foot of the Rocky Mountains. Between this chain and that of the coast (the Maritime Alps of New Albion), there are plains in which wood is scarce; but in passing the Maritime Alps, the forests recommence, and the country as far as the mouth of the Rio Columbia, presents all the advantages of Tennesse and Kentucky.

the geography of plants, but exerts, as we have said above, a great influence on the feeble culture and population north-west of the Lower Mississipi. In the United States, the savannah countries are more slowly *colonized;* and even the tribes of independent Indians, are forced by the rigour of the climate to pass the winter along the rivers, where poplars and willows are found. The basins of the Mississipi, of the lakes of Canada and the Saint Lawrence, are the largest of America; and although the total population does not rise at present beyond three millions *, it may be considered as that in which, between the 29° and 45° of latitude, (long. 74° —94°), civilization has made the greatest progress. It may even be said, that in the other basins (of the Oroonoko, the Amazon, and Buenos Ayres), agricultural life scarcely exists; it begins on a small number of points only, to replace pastoral life, and that of fishing and hunting nations. The plains between the Alleghanies and the Andes of Upper Louisiana are of so vast an extent, that similar to the Pampas † of Choco and

* Vol. vi, p. 142.

† The Palm-trees extend towards the south, in the Pampas of Buenos Ayres, and in the Cisplatine province, to 34° and 35°. (*Auguste de Saint Hilaire, Apercu d'un Voyage au Bresil*, p. 60.)

Buenos Ayres, Bambousacees (*Ludolfia, Miega*) and Palm-trees grow at one of their extremities, while the other during a great part of the year is covered with ice and snow.

β. The basin of the gulph of Mexico, and of the Caribbean Sea. This is a continuation of the basin of the Mississipi, Louisiana, and Hudson's Bay. It may be asserted, that all the low lands on the coast of Venezuela which are preserved on the north of the chain of the shore, and of the *Sierra Nevada de Merida*, belong to the submerged part of this basin. If I treat here separately concerning the basin of the Caribbean Sea, it is to avoid confounding what, in the present state of the globe, is above and below the surface of the waters. I have already shewn in another place, how much the recent coincidence of the epochs of earthquakes observed at Caraccas, and on the banks of the Mississipi, the Arkansas and the Ohio *, justifies the geologic views which regard as one basin the plains bounded on the south, by the Cordillera of the shore of Venezuela; on the east, by the Alleghanies and the series of the volcanoes of the West Indies; and on the west, by the Rocky Mountains (Mexican

* Vol. iv, p. 9.

Andes) and by the series of the volcanoes of Guatimala. The basin of the West Indies forms, as we have already observed, a *Mediterranean with several issues*, the influence of which on the political destinies of the New Continent depends at the same time on its central position and the great fertility of its islands. The issues of the basin, of which the four largest * are 75 miles broad, are all on the eastern side, open towards Europe, and agitated by the current of the tropics. In the same manner as we recognize in our Mediterranean, the vestiges of three ancient basins by the proximity of Rhodes, Scarpento, Candia, and Cerigo, as well as by that of Cape Sorello of Sicily, the island of Pantelaria and Cape Bon of Africa; in the same manner the basin of the West Indies, which surpasses the Mediterranean in extent, seems to present the remains of ancient dykes that join † Cape Catoche of Yucutan, to Cape

* Between Tabago and Grenada; the isle Saint Martin and the Virgin Isles, Porto Rico and Saint Domingo, and between the Small Bank of Bahama and Cape Cañaveral of Florida.

† I do not pretend that this hypothesis of the rupture and the ancient continuity of lands can be extended to the eastern foot of the basin of the West Indies, that is, to the series of volcanic islands in a line from Trinidad to Portorico. *See* the information I gave, Vol. iv, p. 36, &c.

Saint Antoine of the island of Cuba; and that island Cape Tiburon of Saint Domingo, Jamaica, the Bank of La Vibora, and the rock of Serranilla to Cape Gracias a Dios on the coast of the Mosquitos. From this disposition of the most prominent islands and capes of the continent, there results a division into three partial basins. The most northerly has long been marked by a particular denomination, that of the *Gulph of Mexico;* the intermediary or central basin may be called the *Sea of Honduras,* on account of the gulph of that name which makes a part of it; and the southern basin, comprehended between the Caribbean islands and the coast of Venezuela, the isthmus of Panama, and the country of the Mosquitos Indians, would form the Caribbean Sea*. The modern volcanic rocks distributed on the two opposite banks of the basin of the West Indies on the east and west, but not on the north and south, is also a phenomenon well worthy of attention. In the Caribbean islands, a groupe of volcanoes, partly extinguished and partly burning,

* This denomination is so much the more exact when appropriated to the southern part of the basin of the West Indies, that the people of Carib race were disseminated on the neighbouring continent and in the Archipelago, from the Caribana of Darien as far as the Virgins. *See* above, Vol. vi, p. 22 and 329.

stretches from 12° to 18°; and in the Cordilleras of Guatimala and Mexico from 9° to 19½° of latitude. I saw at the north-west extremity of the basin of the West Indies the secondary formations dip towards the south-east; along the coast of Venezuela, rocks of gneiss and primitive mica-slate dip towards the north-west. The basalts, amygdaloides, and trachytes, which are often surmounted by tertiary lime-stones, appear only towards the eastern and western banks.

8. THE BASIN OF THE LOWER OROONOKO, OR THE PLAINS OF VENEZUELA. This basin, like the plains of Lombardy, is open to the east. Its limits are the chain of the shore of Venezuela on the north; the eastern Cordillera of New Grenada on the west; and the Sierra Parime on the south; but as the latter groupe extends on the west, only to the meridian of the cataracts of Maypures (long. 70° 37'), there remains an opening or land-strait, running from north to south, by which the Llanos of Venezuela communicate with the basin of the Amazon and the Rio Negro. We distinguish between the *basin of the Lower Oroonoko properly so called* (on the north of that river and the Rio Apure), and the *plains of Meta and Guaviare*. The latter

fill the space between the mountains of Parime and New Grenada. The two parts of this basin have an opposite direction; but being alike covered with gramina, they are usually comprehended in the country under the same denomination. Those Llanos (*steppes, savannahs, or prairies*) extend in the form of an arch from the mouth of the Oroonoko, by San Fernando de Apure, to the confluence of the Rio Caguan with the Jupura, consequently on a length of more than 360 leagues.

1.) *Part of the basin of Venezuela running from east to west.* The general slope is towards the east, and the mean height from 40 to 50 toises. The western bank of that great *sea of verdure* (*mar de yerbas*) is formed by a groupe of mountains, several of which equal or surpass in height the Peak of Teneriffe and Mont Blanc. Of this number are the Paramos del Almorzadero, Cacota, Laura, Porquera, Mucuchies, Timotes, and Las Rosas. The northern and southern banks are generally less than 500 or 600 toises high. I have given elsewhere an ample description of the soil of the *Llanos* (Vol. iii, p. 285, 349; Vol. iv, p. 293, 300, 313, 317, 330, 394; Vol. v, p. 670; Vol. vi, p. 4, 17, 43, 73.) It is remarked with some surprise, that the *maximum*

of the depression of the basin is not in its center, but on its southern limit, at the Sierra Parime, along which runs the *thalweg* of the Oroonoko. It is only between the meridians of Cape Codera and Cumana, where a great part of the Cordillera of the shore of Venezuela has been destroyed, that the waters of the *Llanos* (the Rio Unare and the Rio Neveri) reach the northern coast. The ridge of partition of this basin is formed by small table-lands, known by the names of Mesas d'Amana, Guanipa, and Jonoro. (Vol. iv, p. 30; Vol. vi, p. 48.) In the eastern part, between the meridians 63° and 66°, the plains or savannahs pass, towards the south, beyond the bed of the Oroonoko and the Imataca, and form (in approaching the Cujuni and the Essequibo,) a kind of gulph along the Sierra Pacaraina (Vol. v, p. 760; Vol. vi, p. 504).

2.) *Part of the basin of Venezuela running from south to north.* The great breadth of this zone of savannahs, of from 100 to 120 leagues, renders the denomination of *land-strait* somewhat improper, at least if it be not geognostically applied to every communication of basins bounded by high Cordilleras. Perhaps this denomination rather belongs to that part where the groupe

of almost unknown mountains is placed, that surround the sources of the Rio Negro. (Vol. vi, p. 512). In the basin comprehended between the eastern declivity of the Andes of New Grenada, and the western part of the Sierra Parime, the savannahs, as we have observed above, stretch far beyond the equator, but their extent does not determine the southern limits of the basin we here examine. The latter are fixed by a ridge that divides the waters between the Oroonoko and the Rio Negro, a tributary stream of the Amazon. The rising of a counterslope almost imperceptible to the eye, forms a ridge that seems to join the eastern Cordillera of the Andes to the groupe of Parime *. This ridge runs from Ceja (lat. 1° 45′), or the eastern slope of the Andes of Timana †, between the sources of the Guayavero and the Rio Caguan ‡, towards the isthmus that separates the Tuamini from Pimichin §. In the *Llanos*, consequently, it follows the parallels of 20° 30′ and 2° 45′. It is remarkable, that we find the *divortia aquarum* more to the west, on

* Vol. vi, p. 397.

† *See* my Map of Magdalena (*Geogr. Atlas*, pl. xxiv).

‡ The former is a tributary stream of the Guaviare, the latter of Yupura.

§ Isthmus of Javita, or portage of Pimichin (Vol. v, pp. 259, 260, 279, *Geogr. Atlas*, pl. xvi).

the back of the Andes, in the knot of mountains containing the sources of the Magdalena, at a height of 900 toises above the level of the *Llanos*, between the Caribbean Sea and the Pacific Ocean *, almost in the same latitude (1° 45′—2° 20′). From the isthmus of Javita towards the east, the *line of the partition of the water* is formed by the mountains of the groupe of Parime; it first rises a little on the north-east towards the sources of the Oroonoko (lat. 3° 45′?) and the chain of Pacaraina † (lat. 4° 4′—4° 12′); afterwards, during a course of 80 leagues, between the portage of the Anocapra ‡ and the banks of the Rupunúri, runs very regularly from west to east; and finally, beyond the meridian 61° 50′, again deviates towards lower latitudes, passing between the northern sources of the Rio Suriname, the Maroni, and the Oyapok, and the southern sources of Rio Trombetas, Curupatuba, and Paru (lat. 2°—1° 50′). These indications suffice to prove that this *first line of partition of the water* of South America (that of the northern hemisphere) traverses the whole continent between the parallels of 2° and 4°. The Cassiquiare only has cut its

* Vol. v, p. 325, 326; Vol. vi, p. 439.

† Vol. vi, p. 520.

‡ Road from Rio Borneo to Rio Carony.

way across the ridge we have just described. The hydraulic system of the Oroonoko displays the singular phenomenon of a bifurcation where the limit of two basins (of the Oroonoko and the Rio Negro) traverses the bed of the principal recipient. In that part of the basin of the Oroonoko which lies from south to north, as well as in that lying from west to east, the *maxima* of the depression are found at the foot of the Sierra Parime, we may even say on its outline.

δ. The Basin of the Rio Negro and the Amazon. This is the central and largest basin of South America. It is exposed to frequent equatorial rains, and the hot and humid climate developes a force of vegetation to which nothing in the two continents can be compared. The central basin, bounded on the north by the groupe of Parime, and on the south by the mountains of Brazil, is almost entirely covered by thick forests, while the two basins placed at the two extremities of the continent (the *Llanos* of Venezuela and the Lower Oroonoko, and the *Pampas* of Buenos Ayres or the Rio de la Plata) are savannahs or *prairies*, plains destitute of trees and covered with gramina. This symetric distribution of savannahs bounded by impenetrable forests, must be connected with

physical revolutions which have acted * at once on great surfaces.

1.) *Part of the basin of the Amazon, running from west to east,* between 2° north and 12° south, is 880 leagues in length. The western shore of this basin is formed by the chain of the Andes, from the knot of the mountains of Huanucò to that of the sources of the Magdalena. It is enlarged by the counterforts of the Rio Beni †, rich in gem-salt, and composed of several ranges of hills (lat. 8° 11′ south) that advance in the plains on the eastern bank of the Paro. These hills are transformed on our maps into *Upper Cordilleras* and *Andes of Cuchao* ‡. Towards the

* Vol. iv, 336; Vol. vi, p. 61, &c. *Martius, Phys. der Pflanzen von Bras.*, p. 13.

† Vol. vi, p. 442. The real name of this great river, respecting the course of which geographers have been so long divided, is *Uchaparu*, probably *water* (*para*) of *Ucha*; *Beni* also signifies *river, water;* for the language of the Maypures has multiplied analogies with that of the Moxos (Vol. v, p. 148); and *veni* (*oueni*) signifies water in Maypure, as *una* in Moxo. Perhaps the river retained the name of Maypure, when the Indians who spoke that language had emigrated to the north, towards the banks of the Oroonoko.

‡ *The Andes of Cuchao*, placed in Arrowsmith's map at 10½°-12° north of the fabulous lake of Rogagualo, are nothing more than the mountains of Cuchao, placed by La Cruz, lat. 13°, south-west of that lake. This geographer by

north, the basin of the Amazon, of which the *area* (244,000 square leagues) is only a sixth less than the *area* of all Europe, rises in a gentle slope towards the Sierra Parime. At 68° of west longitude the elevated part of this Sierra terminates at $3\frac{1}{2}$° of north latitude. The groupe of monticules that surround the source of the Rio Negro, the Inirida and the Xie (lat. 2°) the scattered rocks between the Atabapo and the Cassiquiare, appear like groupes of islands and rocks in the middle of the plain. A part of those rocks is covered with signs or symbolical sculpture. Nations, very different from those who now inhabit the banks of the Cassiquiare, penetrated into the savannahs; and the zone of *painted rocks*, extending more than 150 leagues in breadth, presents traces of ancient civilization. On the east of the sporadic groupes of rocks (between the meridian of the bifurcation of the Oroonoko and that of the confluence of the Essequibo with the Rupunuri), the lofty mountains of Parime commence only at 3° of latitude;

a strange error, has covered plains with mountains of which they are entirely destitute. He forgot that in the colonies, *monte* signifies almost exclusively a forest, and he has traced chains of mountains wherever he has written *montes de cacao*, as if the cacao-tree did not belong to the hottest region of the plains.

where the plains of the Amazon terminate. The vast gulph which they seem to form in the upper part of the basin of the Rio Branco, and the windings of the southern slope of the Sierra Parime, have been discussed above *. The limits of the plains of the Amazon are still more unknown towards the south than towards the north. The mountains that exceed 400 toises do not appear to extend in Brazil on the north of the parallel of 14° to 15° of south latitude, and west of the meridian of 52°; but it is not known how far the *mountainous country* is prolonged, if we may call by that name a territory bristled with hills of one hundred or two hundred toises high. Between the Rio das Vertentes and the Rio de Tres Barras (tributary streams of the Araguay and the Topayos), several ridges of the *Mounts Parecis* run towards the north. On the right bank of the Topayos, a series of monticules advance (according to manuscript maps recently framed at the hydrographic Depôt of Rio Janeiro) as far as the parallel of 5° south latitude, to the fall *(cachoeira)* of Maracana; while further west, in the Rio Madeira, of which the course is nearly parallel with that of the Topayos, the rapids and cataracts (of which seventeen are rec-

* Vol. vi, p. 520, &c.

koned between Guayramerim * and the famous Salto of Theotonio †) indicate no rocky ridges beyond the parallel of 8°. The principal depression of the basin of which we have just examined the outline, is not found near one of its banks, as in the basin of the Lower Oroonoko, but at the center, where the great recipient of the Amazon forms a longitudinal furrow inclined from west to east, under an angle of at least 25 seconds ‡. The barometric measures which I made at Javita on the banks of the Tuamini, at Vasiva on the banks of the Cassiquiare, and at the cataract of Rentema, in the Upper Maragnon, seem to prove that the rising of the plains of the Amazon towards the north (at the foot of the Sierra Parime), is 150 toises, and, towards the west (at the foot of the Cordillera of the Andes of Loxa), is 190 toises, above the level of the Ocean §. It is to be hoped, that when steam-boats go up the Amazon from Grand Para as far as Pongo

* Above the confluence of the Madeira and Mamorè, which a Brazilian journal, justly esteemed (*Patriota*, 1813, p. 288), places in 10° 22′ 30″ of latitude, while it marks the confluence of the Madeira with the Guaporè, at 11° 54′ 46″.

† Above the confluence of the Madeira and the Jamary.

‡ *See above*, Vol. vi, p. 395, note.

§ Vol. v, p. 251, 347, 550, 551, and *Rec. d'Obs. Astr.* Vol. i. p. 315.

de Manseriche, in the province of Maynas, the barometric measurement of the course of this river, which is the *thalweg* of a plain fifteen times the extent of the whole of France, will not be neglected.

2.) *Part of the basin of the Amazon stretching from south to north.* This is the zone or land strait by which, between 12° and 20° of south latitude, the plains of the Amazon communicate with the *Pampas* of Buenos Ayres. The western bank of this zone is formed by the Andes, between the knot of Porco and Potosi, and that of Huanuco and Pasco. Part of the *counter-forts of the Rio Beni*, which is but a widening of the Cordilleras of Apolobamba and Cuzco *, and the whole promontory of Cochabamba †, advance towards the east in the plains of the Amazon. The prolongation of this promontory has given rise to the idea that the Andes are linked with a series of hills which the *Serras dos Parecis* ‡, the Serra Melgueira, and the pretended Cordillera of San Fernando, throw out towards the west. The almost unknown part of the frontiers of Brazil and Upper

* Vol. vi, p. 432.
† Vol. vi, p. 419.
‡ Vol. vi, p. 538.

Peru merit the attention of travellers. It appears from the most recent notions we can collect, that the ancient mission of San Jose of Chiquitos (nearly lat. 17°; long. 67° 10′, supposing Santa Cruz de la Sierra, lat. 17° 25′; long. 66° 47′), is situated in the plains, and that the mountains of the counter-fort of Cochabamba terminate between the Guapaix (Rio de Mizque) and the Parapiti, which lower down takes the names of Rio San Miguel and Rio Sara. The savannahs of the province of Chiquitos communicate on the north with those of Moxos, and on the south with those of Chaco *; but, as we have observed above, a ridge or line of partition of the water is formed, by the intersection of two plains slightly sloped, which takes its origin on the north of La Plata (Chuquisaca) between the sources of the Guapaix and the Cachimayo, (a tributary stream of the Pilcomayo), and ascends from the parallel of 20° to that of 15½° of south latitude, consequently on the north-east, towards the isthmus of Villabella †. From this point, one of the most important of the whole hydrography of America, we can follow the line of the partition of the water to

* *Carta de las Missiones de los Moxos de la Compañia de Jesus de el Perù*, 1709.

† Between the tributary stream of the Paraguay and the Madeira, Vol. vi, p. 535.

the Cordillera of the shore *(Serra do Mar)*. It is seen winding (lat. 17°-20°) between the northern sources of the Araguay, the Maranhao or Tocantines, and the Rio San Francisco, and the southern sources of the Parana. This *second line of partition*, which enters into the groupe of the mountains of Brazil, on the frontier of the Capitainerie of Goyaz, separates the flowings of the basin of the Amazon from those of the Rio de la Plata, and corresponds, south of the equator, with the line we have indicated in the northern hemisphere (lat. 2°-4°), on the limits of the basins of the Amazon and the Lower Oroonoko *.

If the plains of the Amazon (taking that denomination in the geognostic sense we have given it) are distinguished in general from the *Llanos* of Venezuela and the *Pampas* of Buenos Ayres, by the extent and thickness of their forests, we are so much the more struck by the continuity of the savannahs in that part running from south to north. It would seem as if this *sea of verdure* stretched forth an arm from the basin of Buenos Ayres, by the *Llanos* of Tucuman, Manso, Chuco, the Chiquitos, and the Moxos, to the *Pampas* del Sacramento †, and the

* Vol. vi, p. 577.

† This Pampas, which Sobreviela first made known, bears

savannahs of Napo, Guaviare, Meta, and Apure *. This arm crosses, between 7° and 3° of south latitude, the basin of the forests of the Amazon, and the absence of trees on so great an extent of territory (the preponderance which the small monocotyledon plants have acquired) is a phenomenon of the geography of plants which belongs perhaps to the action of ancient pelagic currents, or other partial revolutions of our planet.

PLAINS OF THE RIO DE LA PLATA, AND OF PATAGONIA, from the south-west slope of the groupe of the mountains of Brazil, to the strait of Magellan, from 20° to 53° of latitude. These plains correspond with those of the Mississipi, and of Canada in the northern hemisphere. If one of their extremities draws less nigh the polar regions, the other enters so much further into the region of palm trees.

also the name of *Pajonal* (plain which produces *straw*), between the Rio Paro, a tributary stream of the Ucayali and the banks of the Huallaga.

* I have named the plains covered with gramina, in the order in which they succeed each other from south to north, from the 30° of south, to the 9° of north-latitude. The savannahs between the Rio Vermejo and the Pilcomayo, (south lat. 22°-25½°) are called *Llanos de Manso*, after the name of a Spaniard who made the first essays of cultivation in those desert countries. (*Brackenridge*, Vol. 2, p. 17).

That part of this vast basin extending from the eastern coast towards the Rio Paraguay, (that is the Capitania of Rio Grande, west of the island Saint Catherine, the Cisplatine province of Paraguay properly so called, between the Parana and the Rio Paraguay) does not present a surface so perfectly smooth as the part situated on the west and south-east of the Rio de la Plata, and which has been known for ages by the name of Pampas, derived from the Peruvian or Quichua language *. Geognostically speaking, these two regions of east and west form only one basin, bounded on the east by the Sierra de Villarica or do Espinhazo, which loses itself in the Capitania of Saint Paul, towards the parallel of 24°; issuing on the north-east by the monticules †,

*. *Hatan Pampa* signifies in that language, a great plain. We find the word *Pampa* also in *Riobamba* and *Guallabamba*; the Spaniards, in order to soften the geographical names, change the *p* into *b*.

† On the south of the Villa of Cuyaba, or rather on the south of the Rio Mbotetey (Emboteteu or Mondego), a mountainous country stretches towards the south, known by the pompous names of *Cordilleras* of Amambay, of San Jose, and of Maracajou. According to the fine manuscript map of the ancient viceroyalty of Rio de la Plata (by Don Miguel de Lastarria, 1804), of which I owe the communication to the kindness of M. Malte-Brun, the whole northern part of Paraguay, between the mission of Curuguati (lat. 24½°) and the rivers Mbotetey and Monice (Yaguari) is full of hills.

from the Serra da Canastra and the Campos Parecis towards the province of Paraguay; on the west, by the Andes of Upper Peru and Chili; and on the north-west, by the ridge of the partition of the waters which runs from the counter-fort of Santa Cruz de la Sierra, across the plains of the Chiquitos, towards the Serras of Albuquerque (lat. 19° 20′) and San Fernando. That part only of this basin lying on the west of the Rio Paraguay, and which is entirely covered with gramina (thick forests extend towards Parana, and the sources of the Uruguay), is 70,000 square leagues. This surface of the *Pampas* or *Llanos* of Manse, Tucuman, Buenos Ayres, and eastern Patagonia, exceeds consequently four times the surface of the whole of France. The Andes of Chili narrow the *Pampas* by the two counterforts of Salta and Cordova *: the latter promontory, of which we know with precision the extent by the astronomical

Geographers also figure a chain of mountains between 28° and 34½° of latitude, in the province of the Missions and the Cisplatine province of Brazil, a chain supposed to separate the waters of the Uraguay from those of the eastern coast; but these Cordilleras are probably not 200 toises high. In comparing the maps of d'Anville, Varela, Dobrizhoffer, and Azara, we perceive that with the progress of geography the mountains of those countries gradually disappear.

* Vol. vi, p. 418.

observations of M.M. Espinosa and Bauza *, forms so projecting a point, that there remains (lat. 31°-32°) a plain only 45 leagues broad between the eastern extremity of the Sierra de Cordova and the right bank of the river Paraguay, stretching in the direction of a meridian, from the town of Nueva Coimbra to Rosario, below Santa Fe. Far beyond the southern frontiers of the ancient viceroyalty of Buenos Ayres, between the Rio Colorado and the Rio Negro (lat. 38°-39°) groupes of mountains seem to rise in the form of islands, in the middle of a muriatiferous plain. A tribe of Indians of the south † *(Tehuellet)*, have there long borne

* The officers of the Spanish marine quitted the expedition of Malaspina at Lima to rejoin it at Buenos Ayres. They determined the latitude and longitude of Mendoza (lat. 32° 52′; long. 71° 23′) and S. Luis de la Punto (lat. 33° 18′; long. 68° 4′). *Memorias de los Navegantes*, Vol. i, Appendix, p. 181). We find the town of Cordova, according to those positions, to be lat. 31° 22′; long. 66° 17′; admitting with M. Bauza, according to the *Map of the southern Ocean comprehended between Cape Horn and the Cape of Good Hope*, (Madrid, 1804,) the town of Cordova to be 1° 47′ the east of San Luis de la Punta, La Cruz, and Arrowsmith supposed this distance to be 3° 20′ and 3° 4′. M. Bauza, who has visited that country, admits the difference of longitude of Cordova and Santa Fe to be 3°, while Arrowsmith makes 2° 36′. Observations are wanting between Tucuman, Asuncion, and Santa Fe.

† *Het*, man; *tehuel*, noon.

the characteristic name of *men of the mountains* (*Callilehet*) or *Serranos*. From the parallel of the mouth of the Rio Negro to that of Cabo Blanco (lat. 41°—47°), scattered mountains on the eastern Patagonia coast denote more considerable inequalities in the inlands. All that part however of the strait of Magellan, from the Cape of Virgins to the North Cape, on a breadth of more than 30 leagues, is surrounded by savannahs or Pampas, and the Andes of western Patagonia only begin to rise near the latter cape, exerting a marked influence on the direction of that part of the strait nearest the South Sea, and going from S. E. to N. W.

If we have given the plains or great basins of South America, the names of the rivers that flow in their longitudinal furrows, we have not meant by so doing to compare them to simple vallies. In the plains of the Lower Oroonoko and the Amazon, all the lines of the declivity reach no doubt a principal recipient, and the tributaries of tributary streams, that is the *basins of different orders*, penetrate far into the groupe of the mountains. The upper part or high vallies of the tributary streams are considered in a *geological table*, as belonging to the mountainous region of the country, and placed beyond the plains of the Lower Oroo-

noko and the Amazon. The views of the geologist are not identical with those of hydrography. In the basin which we have called that of the Rio de la Plata and Patagonia, the waters that follow the lines of the greatest declivities have many issues. The same basin contains several vallies of rivers; and when we examine nearly the polyedric surface of the *Pampas* and the portion of their waters which, like the waters of the steppes of Asia *, do not go to the sea, we conceive that these plains are divided by small ridges or *lines of elevation*, and have alternating slopes †, inclined, with respect to the horizon, in opposite directions. In order to point out more clearly the difference between geological and hydrographic views, and prove that in the former, abstracting the course of the waters which meet in one recipient, we obtain a far more general point of view, I shall here again recur to the *hydrographic basin* of the Oroonoko. That immense river rises on the southern slope of the Sierra Parime; it is bounded by plains on the left bank, from the Cassiquiare to the mouth of the Atabapo, and flows in a basin which *geologically*

* The German geographers mark by the name of *rivers of the steppes* (*steppenflüsse*) every system of running waters which has its *maximum* of depression in an interior lake. *See* above, Vol. iv, p. 149.

† *Journal de l'Ecole polytechnique*, Vol. vii, p. 265.

speaking, according to one great division of the surface of South America in those basins, we have called the basin of the Rio Negro and the Amazon. The low regions, which are bounded by the southern and northern declivities of the mountains of Parime and Brazil, and which the geologist ought to mark by one name, contain, according to the no less precise language of hydrography, two basins of rivers, those of the Upper Oroonoko and the Amazon, separated by a ridge (indication of alternating slopes), that runs from Javita towards Esmeralda. From these considerations it results, that a *geological basin (sit venia verbo)* may have several recipients, several emissaries, divided by small ridges almost imperceptible, and may contain at the same time the waters that go to the sea by different furrows independent of each other, and the systems of *inland rivers* flowing into lakes more or less charged with saline matter. A basin of a river, or *hydrographic basin*, has but one recipient, one emissary; if, by a bifurcation, it gives a part of its waters to another hydrographic basin, it is because the bed of the river, or the principal recipient, draws so near the banks of the basin or the ridge of partition that the ridge crosses it in part.

The distribution of the inequalities of the surface of the globe does not display any limits strongly marked between the mountainous coun-

try and the low regions, or geologic basins. Even where the real chains of mountains rise like rocky dykes issuing from a crevice, *counter-forts* that are more or less considerable, seem to indicate their lateral heaving-up. While I recognize the difficulty of well circumscribing the groupes of mountains and the basins or continued plains, I have attempted to calculate their surfaces according to the statements contained in the preceding sheets.

SOUTH AMERICA.

I. MOUNTAINOUS PART:

	Square Marine Leagues.
Andes	58,900
Chain of the shore of Venezuela	1,900
Sierra Nevada de Merida	200
Groupe of Parime	25,800
System of the mountains of Brazil	27,600
	114,400

II. PLAINS:

Llanos of Lower Oroonoko, Meta and Guaviare	29,000
Plains of the Amazon	260,400
Pampas of Rio de la Plata, and Patagonia	135,200
Plains between the eastern chain of the Andes of Cundinamarca and the chain of Choco	12,300
Plains of the shore, on the west of the Andes	20,000
	456,900

The whole surface of South America is 571,300 square leagues (20 to a degree), and the relation of the mountainous country to the region of the plains is as 1 : 3,9. The latter region, on the east of the Andes, is more than 424,600 square leagues, the half of which consists of savannahs, that is, it is covered with gramina.

Section II.

General partition of lands.—Direction and inclination of the layers.—Relative height of the formations above the level of the Ocean.

We have examined in the preceding section, the inequalities of the surface of the soil, that is, the general *structure* of the mountains, and the form of the basins left between those mountains variously grouped together. These mountains are sometimes *longitudinal*, by narrow bands or chains, similar to the veins that preserve their tendency at great distances (Andes, mountains of the shore of Venezuela, Serra do Mar of Brazil, Alleghanies of the United States); sometimes they are in masses with irregular forms, in which the heavings-up seem to take place as on a labyrinth of crevices or a *heap* of veins (Sierra Parime, Serra das Vertentes). These modes of formations are linked with an

hypothesis of geognosy *, which has at least the advantage of being founded on facts observed on historic lines, and which strongly characterize the *chains* and *groupes* of mountains. Considerations on the aspect of a country are independent of those which indicate the nature of the soil, the heterogenity of matter, the superposition of the rocks, and the direction and inclination of the beds; the latter will be stated in the second and third sections of this memoir. With respect to the *relief* and the connection of the inequalities of the soil, the half of the lunar globe is now, perhaps, better known than the half of the terrestrial globe, and the *geology of formations*, for ever inaccessible to physical astronomy, if not devoted to dangerous errors, advances with extreme slowness, even in the countries of Europe nearest to each other.

In taking a general view of the geological constitution of a chain of mountains, we may distinguish *five elements of direction* too often confounded in works of geognosy and physical geography. These elements are:—

* *See* the new and important observations on the origin of the chains of mountains, in a work well fitted to fix the attention of geognosts: *Resultatn der neuesten geogn. Forschungen des Herre Leopold von Buch, zusammonges tellet und ubersezt von K. C. von Leonhard*, p. 307, 382, 438, 470, 475, 506.

α.) The Longitudinal axis of the whole chain.

β.) The line that divides the waters *(divortia aquarum)*.

γ.) The line of ridges or elevation passing along the maxima of height.

δ.) The line that separates into horizontal sections, two contiguous formations.

ε.) The line that follows the rents of stratification.

This distinction is so much the more necessary, as there exists probably no chain on the globe that furnishes a perfect parallelism of all these *directing lines*. In the Pyrenees, for instance, α, β, γ do not coincide, but δ and ε (that is, the different bands of formations which come *to light* successively, and the direction of the strata) are sensibly parallel to α, or to the direction of the whole chain *. We find so often in the most distant parts of the globe, a perfect parallelism between α and ε, that it may be supposed that the causes which determine the direction of the axis (the angle under which that axis cuts the meridians), are generally linked with causes that determine the direction and

* The direction of the longitudinal axis α in the Pyrenees, and that of the formations δ, which appear successively at the surface of the soil, as in long bands, are N. 68° 73° W. Now, as the line of the *maxima* of height γ, is not parallel with the axis α, it results from the fine observations of MM. Palassou, Ramond and Charpentier, that it must necessarily pass by very different formations.

inclination of the strata. This direction of the strata is independent of that of the bands of formations, or their visible limits at the surface of the soil; the lines δ and ϵ sometimes cross each other, even when one of them coincides with α, or with the direction of the longitudinal axis of the whole chain. The *relief* of a country cannot be explained with precision on a map, nor can the most erroneous opinions on the place and superposition of soils be avoided, if we do not seize with clearness the relations of the *directing lines* which we have just mentioned.

In that part of South America which makes the principal object of this memoir, and which is bounded by the river Amazon on the south, and on the west by the meridian of the snowy mountains (*Sierra Nevada*) of Merida, the different bands or zones of formations δ, are sensibly parallel with the longitudinal axis α of the chains of mountains, basins, or interposed plains. It may be said in general that the *granitic zone*, (uniting under that denomination the rocks of granite, gneiss, and mica-slate) follows the direction of the Cordillera of the shore of Venezuela, and belongs exclusively to that Cordillera and the groupe of the mountains of Parime; since it no where pierces the secondary and tertiary soils in the *Llanos* or basin of the Lower Oroonoko. It thence re-

sults, that the same formations do not constitute the region of plains and of mountains.

If we may be permitted to judge of the structure of the whole *Sierra Parime*, from the considerable part which I have examined in 6° of longitude, and 4° of latitude, we may believe it to be entirely composed of gneiss-granite; I saw some beds of green-stone, and amphibolic slate, but neither mica-slate, clay-slate, nor banks of green lime-stone, although many phenomena render the presence of the former of those rocks probable, on the east of the Maypures and in the chain of Pacaraïna. The geological formation of the groupe of Parime, is consequently still more simple than that of the Brazilian groupe, in which granites, gneiss, and mica-slate, are covered with thonschiefer, chloritous quartz (Itacolumite), grauwakke, and transition limestone*; but those two groupes have in common, as we have already mentioned, the absence of a real system of secondary rocks; we find in both some fragments only of sand-stone or silicious conglomerate. In the Cordillera of the *shore of Venezuela* †, the granitic formations predominate; but they are wanting towards the east, and especially in the southern chain, where we

* *See* my Essay on the position of rocks, p. 96, and Eschwege, Geogn. Gemalde, pp. 7, 17, 24.

† On its limits and divisions, *see* Vol. vi, pp. 485—505.

observe (in the missions of Caripe and around the gulph of Cariaco) a great accumulation of secondary and tertiary calcareous rocks. From the point where the Cordillera of the shore is linked with the Andes of New Grenada (long. 71½°), we observe first the granitic mountains of Aroa and San Felipe, between the rivers of Yaracui and Tocuyo*; these granitic formations extend on the east of the two coasts of the basin of the *Vallies of Aragua*, in the northern chain, as far as Cape Codera; and in the southern as far as the mountains (*Altas Savanas*) of Ocumare. After the remarkable interruption of the Cordillera of the shore, in the province of Barcelona, the granitic rocks begin to appear in the Island of Marguerita and in the isthmus of Araya, and continue perhaps towards the *Bocas del Drago*; but on the east of the meridian of Cape Codera, the northern chain only is granitic (of micaceous slate); the southern chain (Morro de Nueva Barcelona, Archipelago of the Caraccas islands, Cerro del Bergantin, vicinity of Cumanacoa, Cocollar and Caripe,) is entirely composed of secondary limestone and sandstone.

* Manuscript notes of General Cortes: my own observations begin only in the meridian of Portocabello (long. 70° 37′) and terminate at that of Cerro de Meapire (long. 65° 51′), near Cariaco.

If, in the *granitic soil* which is here a very *complex formation*, we would distinguish mineralogically between the rocks of granite, gneiss, and micaslate, we must recollect that according to my local observations, the granite with large grains, not passing to gneiss, is very rare in this country. It belongs peculiarly to the mountains that bound the basin of the lake of Valencia towards the north; for in the islands of that lake, in the mountains near the town of Cura, and in the whole northern chain, between the meridian of Victoria and Cape Codera, gneiss predominates, sometimes alternating (Silla de Caraccas) with granite, or passing (between Guigue and Villa de Cura, mountain of Chacoa) to micaslate *. The micaslate is the most frequent rock in the peninsula of Araya † and the groupe of Macanao which forms the western part of the island of Marguerita. On the west of Maniquarez, the micaslate of the peninsula of Araya loses by degrees (Cerro de Chuparuparu) its half-metallic lustre; it is charged with carbon and becomes a clayslate (thonschiefer) ‡, even an ampelite (alaunschiefer). The beds of granular limestone are most common in the primitive northern chain, and, which is some-

* Vol. iv, p. 273, &c.

† Vol. ii, p. 291.

‡ Vol. vi, p. 101.

what remarkable, they are found in gneiss, and not in micaslate.

We find at the back of this granitic, or rather micaslate-gneiss soil of the southern chain, on the south of the Villa of Cura, a *transition soil*, composed of greenstone, amphibolic serpentine, micaceous limestone, and green and carburated slate *. The most southern limit of this territory is formed by *volcanized rocks*. Between Parapara, Ortiz, and the Cerro de Flores (lat. 9° 28′—9° 34′; long. 70° 2′—70° 15′), phonolithes and amygdaloides are found on the very border of the basin of the *Llanos*, that vast internal sea which heretofore filled the whole space between the Cordilleras of Venezuela and Parime. We shall here remark that, according to the observations of Major Long and Doctor James, trappean formations (bulleuses dolerites and amygdaloides with pyroxene) also border the plains or basin of the Mississipi, towards the west, at the declivity of the Rocky Mountains †. The ancient pyrogenie rocks which I found near Parapara where they rise in mounds with rounded summits, are the more remarkable as no others have been hitherto dis-

* Vol. iv, 279, &c.

† From the sources of the Canadian river to the Rio Colorado de Natchitotches. *See Long. Exped.* Vol. ii, p. 91, 402.

covered in the whole eastern part of South America. The close connection observed in the soil of Parapara, between greenstone, amphibolic serpentine, and amygdaloides containing crystals of pyroxene; the form of the Morros of San Juan, which rise like cylinders above the table-land; the granular texture of their limestone surrounded by trapean rocks, are objects worthy the attention of the geologist, who has studied in the southern Tyrol, the effects produced by the contact of poroxenic porphyrys *.

The *calcareous soil* of the Cordillera of the shore is most frequent, as we have already observed, on the east of Cape Unare, in the southern chain; it extends to the gulph of Paria, opposite the island of Trinidad, where we find gypsum of Guire, containing sulphur. I have been assured that in the northern chain also, in the *Montaña de Paria*, and near Carupana, secondary calcareous formations are found, and that they only begin to appear on

* *Leopold de Buch, Tableau geologique du Tyrol*, p. 17. I learn by very recent letters from M. Boussingault, that these singular Morros de San Juan which furnish a limestone with crystalline grains, and thermal springs, are hollow, and contain immense grottos filled with stalactites, which appear to have been anciently inhabited by the natives.

the east of the ridge * of rock (Cerro de Meapire) which joins the calcareous groupe of Guacharo to the groupe of micaslate of the peninsula of Araya; but I have not had occasion to verify the justness of this observation. The calcareous soil of the southern chain is composed of two formations which appear distinct, the limestone of Cumanacoa and that of Caripe. While I was on the spot, the former appeared to me to have some analogy with the zechstein, or alpine limestone; the latter with jurassic limestone; I even thought that the latter granular gypsum of Guire might be that which belongs in Europe to zechstein, or is placed between zechstein and variegated sandstone. Beds of quartzous sandstone, alternating with slaty clay, cover the limestone of Cumanacoa †, Cerro del Impossible, Turimiquiri, Guarda de San Agustin) and the jurassic limestone ‡ in the province of Barcelona (*Aguas calientes*). According to this position, this sandstone may be considered as belonging to the formation of green sandstone, or sandstone with lignites below chalk. But it is little probable if (as I thought I observed at Cocollar) the sandstone forms beds in the alpine limestone, before it is

* Vol. iii, p. 183.

† Vol. iii, p. 10, &c. 23, 163.

‡ Vol. vi, p. 80.

superposed, that the sandstone of the *Impossible*, and the *Aguas calientes*, constitute the same soil. The muriatiferous clay (with petroleum and lamellar gypsum) cover the western part of the peninsula of Araya, opposite the town of Cumana, and at the center of the island of Marguerita. This clay appears placed immediately by micaslate, and covered by the calcareous brechia of tertiary soil. I shall not decide if Araya, rich in disseminated muriate of soda * belongs to the formation of sandstone of the *Impossible*, which from its position may be compared to variegated sandstone (red marl).

Fragments of *tertiary soil* surround indubitably the castle and town of Cumana (Castillo de San Antonio), and they also appear at the southwest extremity of the peninsula of Araya (Cerro de la Vela et del Barigon); at the ridge of Meapire, near Cariaco; at Cabo Blanco, on the west of la Guayra, and on the shore of Portocabello; they are found consequently at the foot of the two slopes of the northern chain of the Cordillera of Venezuela. This tertiary † soil is composed of alternate beds of calcareous aglomerats, compact limestone, marl, and clay, containing selenite, and lamellar gypsum. This

* Vol. iii. p. 94.

† Vol. ii, p. 266—269, 290, 291; Vol. iii, p. 204; Vol. vi, p. 93.

whole system of very new beds appears to me to constitute but one formation, which is found at Cerro de la Papa, near Carthagena, and in the islands of Guadaloupe and Martinico.

Such is the geological distribution of the soils in the mountainous part of Venezuela, in the groupe of Parime, and in the Cordillera of the shore. It remains to characterize the formations of the *Llanos* (or of the basin of the Lower Oroonoko and the Apure); but it is not easy to determine the order of their superposition, because in this region ravines or beds of torrents and deep wells dug by the hands of man are entirely wanting. The formations of the *Llanos* are; 1st. a sandstone or conglomerate, with rounded fragments of quartz, lydian, and kieselschiefer * joined by a ferruginous clayey cement, extremely tenacious, olive brown, sometimes of a vivid red: 2d. a compact limestone (between Timao and Calabozo) which, by its smooth fracture, and lithographic aspect, approaches the Jura limestone: 3d. alternate beds † of marl and lamellar gypsum (Mesa de San Diego, Ortiz, Cachipo). These three formations appeared to me to succeed each other in the order I have just described, the sand-

* *See* Humboldt, *Essai geognostique*, p. 210, and above, Vol. iv, p. 384—387.

† Vol. iv, p. 384; Vol. vi, p. 49.

stone leaning in a concave position towards the north *, on the transition slates of Malpasso, and on the south, on the gneiss granite of Parime. As the gypsum often immediately covers the sandstone of Calabozo, which appeared to me on the spot, to be identical with our soil of red sandstone, I am uncertain of the age of its formation. The secondary rocks of the *Llanos* of Cumana, Barcelona, and Caraccas, occupy a space of more than 5000 square leagues. Their continuity is so much the more remarkable, as they appear to be wanting, at least on the east of the meridian of Porto Cabello (70° 37′) in the whole basin of the Amazon, unless they are covered by granitic sands. The causes which have favoured the accumulation of calcareous matter in the eastern region of the chain of the shore in the *Llanos* of Venezuela (from 10½° to 8° north), have not acted nearer the equator, in the groupe of the mountains of Parime, and in the plains of the Rio Negro and the Amazon (lat. 8° north, to 1° south). The latter plains however, furnish some shelves of fragmented rocks, on the south-west of San Fernando de Atabapo, as well as towards the south-east, in the lower course of the Rio Negro and the Rio Branco. I saw a sandstone in the plains of Jaen de Bracamoros which alternates at the same time with

* Muldenformige Lagerung.

a nks of sand, and conglomerated *galits* of porphyry and lydian *. MM. de Spix and Martius† affirm that the banks of the Rio Negro, on the south of the equator, are composed of variegated sandstone; those of the Rio Branco, Jupura, and Apoporis, of quader sandstone; and those of the Amazon on several points, of ferruginous sandstone‡. It remains to examine if, as I am now inclined to think, the limestone and gypsum formations of the eastern part of the Cordillera of the shore of Venezuela, differ entirely from those of the *Llanos*, and to what soil belongs that rocky wall § which, by the name of *Galera*,

* Geogn. Essay, p. 231.

† *Ueber die Physiognomie des Pflanzenreichs in Brasilien*, p. 13, 14.

‡ *Braunes eisenschussiges Sandstein-Conglomerat* (Ironsand of the English geologists, between the jura-limestone and green sandstone.) MM. Spix and Martius found on rocks of quadersunstein, between the Apoporis and the Japura, the same sculpture which we have made known from the Essequibo to the plains of Cassiquiare, and which seems to prove the migrations of a people more advanced in civilization than the Indians who now inhabit those countries. (Vol. v, p. 600.)

§ Vol. iv, p. 279. Is this wall a succession of rocks of dolomie or a dyke of quadersandstone, like *mer du Diable, (Teufelsmauer,)* at the foot of Harz? Calcareous bands (coral banks) either bands of sandstone (effects of the revulsion of the waves) or volcanic eruptions, are commonly found on the borders of great plains, that is, on the shores of antient inland seas. The *Llanos* of Venezuela furnish examples of

bounds the steppes of Calabozo, towards the north? The basin of the steppes is the bottom of a sea destitute of islands; it is only on the south of the Apure, between that river and the Meta, near the western bank of the Sierra, that some hills appear, Monte Parure *, la Galera de Sinaruco, and the Cerritos of San Vicente. With the exception of the fragments of tertiary soil which we have indicated above, we remark, from the equator to the parallel of 10° north between the meridian of Sierra Nevada de Merida and the coast of Guyana), if not an absence, at least a scarcity of the petrifications which strikes the geognosts recently arrived from Europe.

The *maxima* of the height of the different formations diminish regularly in the country we describe, with their *relative age*. These maxima for *gneiss-granite* (Peak of Duida in the groupe of Parime, Silla de Caraccas, in the chain of the shore) are from 1300 to 1350 toises; for the limestone of Cumanacoa (summit or Cucurucho

those eruptions near Parapara, like the Harudje (*Mons ater Plin.*) in the northern boundary of the African desart (the Sahara). Hills of sandstone rising like towers, walls, and strong castles, and offering a great analogy with the quadersandstone, bound the American desart towards the west, on the south of Arkensas. (Long. Vol. ii, p. 293, 389.)

* Near the Alto de Macachaba (manuscript of the Canon Madariaga).

of Turimiquiri), 1050 toises; for the limestone of Caripe (mountains that surround the table-land of the Guarda of San Agustin), 750 t.; for the sandstone alternating with the limestone of Cumanacoa (Cuchilla de Guanaguana), 550 t.; for the tertiary soil (Punta Araya) 200 t. It appears to me superfluous to remark, that the relations between the age of the formations, and the height they attain, vary definitely in other regions of the globe, where the secondary rocks often rise above the primitive. The study of the absolute height of rocks presents less interest since the geologists for the most part have abandoned the Wernerian hypothesis, of a fluid of which the level has progressively lowered in proportion as the different soils have been precipitated. In the hypothesis which attributes the inequalities of surface to heavings-up, recourse is had to the *waters of granite, gneiss, or micaslate*, which have risen to different heights. The *maxima* of height give only the measure of the force which has acted against the oxidated crust of our planet. According to these views, therefore, the petrifications of pelagic shells which Mr. Bonpland and myself discovered on the ridge of the Peruvian Alps between Montan and Micuipampa, at the height of 2000 toises, in beds strongly inclined, are no proof that the antient level of the ocean had attained that limit.

The extent of country of which I state the geological constitution, is distinguished by the prodigious regularity observed in the *direction of the strata* of which the rocks of different ages are composed. In my personal narrative, and my *Essay on the position of soils*, I have already often fixed the attention of my readers on a geognostic law, which is one of the small number that can be verified by precise admeasurements. Occupied, since the year 1792, by the parallelism or rather the *loxodromism* of the strata, examining the direction and inclination of the primitive and transition-beds, from the coast of Genoa across the chain of the Bochetta, the plains of Lombardy, the Alps of Saint Gothard, the table-land of Swabia, the mountains of Bareuth, and the plains of northern Germany, I was struck with the extreme frequency, if not the constancy of the *hor.* directions 3 and 4 of the compass of Freiberg (direction from south-west to north-east). This research, which I thought might lead to important discoveries on the structure of the globe, had then such an attraction for me that it was one of the most powerful motives of my voyage to the equator. In joining my own observations with those of a great number of able geognosts, we perceive that there *exists in no hemisphere a general and absolute uniformity of direction, but that in regions of very considerable*

extent, sometimes on several thousand square leagues, we observe that the direction, and still more rarely the inclination, has been determined by a system of particular forces. We discover at great distances, a parallelism (loxodromism), a direction, of which the type is manifest amidst partial perturbations, and which often remains the same in primitive and transition soils. The direction of the strata pretty generally, and this fact must have struck Palasson and Saussure, even that of the waters which are far distant from the principal ridges, is identic with the direction of the chains of mountains, that is with their longitudinal axis.

In studying in a given system of rocks the relations which the direction of the strata present, either with the meridians or the horizon of the spot, I proposed to myself for every country, the following quetions: Can we recognize a conformity of direction, a loxodromism of the strata, comprehended in a great extent, where are the perturbations so frequent that no law manifests itself? Is there a simultaneous constancy in the direction and the inclination, or are the strata running N. E.—S. W. sometimes inclined to the N. W., sometimes to the S. E.? Do the laws comprehend the formations of different ages, or may other relations of direction and inclination be observed in the primitive and secondary rocks? Are not the disturbances

themselves subject to certain rules, so that the partial changes of direction are most frequently 90°, and lead to a total change of * inclination? Is there a parallelism between the direction of the strata and that of the nearest chain of mountains, or has that direction of strata a relation with the principal chain, or a very distant oceanic coast? When we call the assemblage of rocks of which the strata have the same direction, a *loxodromic system of rocks*, and when, in a vast country, several of those *loxodromic systems* touch each other, are the changes of direction always sudden, or are there progressive passages on the limit of contiguous systems? The same soil does not furnish the traveller with the means of answering so great a number of important questions; but the progress of positive geognosy can only be ad-

* I allude to the case where, in a chain of mountains of mica-slate-gneiss, the general direction of the strata is *hor.* 4 (from S. W. to N. E.) with the inclination to the N. W., and where the deviations are generally *hor.* 8 (from S. E. to N. W.) The inclination observed in that *inverse direction* will not be as it would be towards the N. E., but towards the S. W. There is therefore a *total change* of inclination from north to south, or rather from N. W. to S. W. This regularity in the mode of deviation, which often occupied my attention in passing over the Andes, has lately engaged the attention of M. Steininger (*Erloschene Vulkane*, p. 3), and of M. Reboul, (*Journ. de Physique*, 1822, December, p. 425), on the banks of the Rhine, and in the Pyrenees.

vanced by never losing sight of the totality of the elements on which the knowledge of the general structure of the globe depends.

Venezuela is one of the countries in which the parallelism of the strata of gneis-granite, mica-slate, and clay-slate is most strongly marked. The general direction of these strata is N. 50° E., and the general inclination from 60° to 70° north-west. Thus I recognized them on a length of more than an hundred leagues, in the chain of the shore of Venezuela; in the stratified granite of las Trincheras near Porto-Cabello (Vol. iv, p. 197); in the gneiss of the isles of the lake of Valencia (Vol. iv, p. 122); and in the vicinity of the Villa de Cura; in the transition slate and greenstone on the north of Parapara (Vol. iv, p. 280); in the way from la Guayra to the town of Caraccas, and in all the Sierra de Avila (Vol. iii, p. 412, &c. and 488); in Cape Codera (Vol. iii, p. 375); and in the mica-slate and clayslate of the peninsula of Araya (Vol. ii, p. 285; Vol. vi, p. 99). The same direction from N. E. to S. W. and this inclination to the N. W., are again observed, although less decidedly, in the limestones of Cumanacoa (Vol. iii, p. 80) at Cuchivano, and between Guanaguana and Caripe. The exceptions * to this general law are extremely rare

* Vol. ii, p. 285; Vol. iii, p. 417—419; Vol. iv, 59, 74—77.

in the gneiss-granite of the Cordillera of the shore; it may even be affirmed, that the *inverse direction* (from S. E. to N. W.) often bears with it the inclination towards the S. W.

As that part of the groupe of the Sierra Parime which I passed over, contains much more granite* than gneiss, and other rocks distinctly stratified, the direction of the layers could be observed in this groupe only on a small number of points; but I was often struck in this region with the constancy of the phenomenon of *loxodromism*. The amphibolic slates of Angostura run N. 45° E. like the gneiss of Guapasoso (Vol. v, p. 224), which form the bed of the Atabapo, and like the micaslate of the peninsula of Araya, although there is a distance of 160 leagues between the limits of those rocks.

The direction of the strata, of which we have just related the prodigious uniformity, is not entirely parallel with the longitudinal axes of the two chains of the shore, and of Parime †. The strata generally cut the former of those chains under an angle of 35°, and their inclina-

* The granite of Baraguan only, is at the same time stratified, and crossed by veins of granite; the direction of the beds is N. 20° W. (Vol. iv, p. 504.)

† Vol. iii, p. 448.

tion towards the north-west, becomes one of the most powerful causes of the dryness which prevails on the southern declivity *, of the mountains of the coast. Can it be admitted that the direction of the eastern Cordillera of New Grenada, which is nearly N. 45° E., from Santa Fe de Bogota, to beyond the Sierra Nevada de Merida, and of which the chain of the shore is but a continuation, has had an influence on the direction (*hor.* 3-4) of the strata in Venezuela? That region presents a very remarkable *loxodromism* with the strata of mica-slate, grauwacke, and the orthoceratite limestone of the Alleghanies, and that immense extent of country (lat. 56°-68°) lately visited by Captain Franklin †. The direction N. E.—S. W. prevails in every part of North America, as in Europe in the Fitchtelgebirge of Franconia, in Taunus, Westerwald, and Eifel, in the Ardennes, in the Vosges, Cotentin, in Scotland, and in the Tarentaise, at the south-west extremity of the Alps ‡. If the strata of rocks in Venezuela do not exactly follow the direction of the nearest Cordillera, that of the shore, the parallelism between the axis of one chain, and the

* Vol. iv, p. 62, &c., 249. This southern declivity is however less rapid than the northern.

† *Journey to the Polar Sea*, 1824, p. 529, 534.

‡ See my *Geognostic Essay*, p. 58.

strata of the formations that compose it, are so much the more manifest * in the groupe of Brazil.

Section III.

Nature of the Rocks.—Relative Age and Superposition of the Formations.—Primitive, transition, secondary, tertiary, and volcanic Soils.

The preceding section has developed the geographical limits of the formations, the extent of the direction of the zones of gneiss-granite, micaslate-gneiss, clayslate, sandstone, and intermediary limestone, which come successively to light. It remains to indicate succinctly the nature and relative age of these formations. In order not to confound *facts* with geognostic *opinions*, I shall describe these formations without dividing them, according to the method generally followed, into five groupes of primitive, transition, secondary, tertiary, and volcanic rocks. I was fortunate enough to discover the types of each groupe in a region where, before my voyage, no rock had

* According to the manuscript notes of M. d'Eschwege, and his *Geogn. Gemälde von Brasilien*, p. 6. The strata of the primitive and intermediary rocks of Brazil run very regularly, like the Cordillera of Villarica (Serra do Espinhaço) *hor.* 1·4 or *hor.* 2 of the compass of Freiberg. (N. 28° E.) The inclination of the strata is generally towards the E.S.E.

been named. The great inconvenience of the antient classifications is that of obliging the geologist to establish fixed demarkations, while he remains in doubt, if not respecting the spot or the immediate superposition, at least on the number of the formations which are not developed. How can we pronounce in many circumstances, on the analogy which a limestone with but few petrifications may present with intermediary limestone, and zechstein, or a sandstone superposed on a primitive rock, with variegated sandstone and quadersandstone, or finally, muriatiferous clay, with the red marl of England, and the gem-salt of the tertiary soils of Italy? When we reflect on the immense progress made within twenty-five years, in the knowledge of the superposition of rocks, it will not appear surprizing that my present opinion on the *relative age* of the formations of Equinoxical America, is not identically the same with what I advanced in 1800. To boast of a stability of opinion in geognosy is to boast of an extreme indolence of mind; it is to remain stationary amidst those who go forward. What we observe in any one part of the earth on the composition of rocks, the subordinate beds they contain, and the order of their position, are facts immutably true, and independent of the progress of positive geognosy in other countries, while the systematic names imposed

on any particular formation of America, are founded only on the supposed analogies between the formations of America and those of Europe. Now, those names cannot remain the same, if, after further examination, the objects of comparison have not retained the same place in the geognostic series; if the most able geologists now take for transition limestone, and green sandstone, what they took formerly for zechstein, and variegated sandstone. I believe the surest means by which geognostic descriptions may be made to survive the change which the science undergoes in proportion to its progress, will be to substitute provisionally, in the description of formations, for the systematic names of red sandstone, variegated sandstone, zechstein, and jura-limestone, names drawn from American localities (sandstone of Llanos, limestone of Cumanacoa and Caripe), and to separate the enumeration of facts which are relative to the superposition of soils, from the discussion on the analogy of those soils * with those of the antient continent.

* The whole of positive geography being nothing but a problem of the *series* or succession (either simple or periodical) of certain terms which represent the formations, it will be necessary, in order to understand the discussions contained in the third section of this memoir, to recapitulate succinctly the *table of formations* considered in the most general point of view. This sketch will rectify what was pub-

I. CO-ORDINATE FORMATIONS OF GRANITE, GNEISS, AND MICASLATE.

There are countries (in France, the vicinity of Lyons; in Germany, Freiberg, Naundorf)

lished nine years ago, Vol. iii, p. 108. 1, *Soil, vulgarly called primitive*; granite, gneiss, and micaslate (or oscillating gneiss, between granite and micaslate); very little primitive clay-slate; weisstein with serpentine; granite with disseminated amphibol; amphibolic slate; veins and short layers of greenstone. 2, *Transition soil*, composed of fragmentary rocks, (grauwacke,) calcariferous slate and greenstone; (first traces of organization: bambousacees, madrepores, productus, trilobites, orthoceratites, evamphalites). Complex and parallel formations. a) alternate beds of grey and stratitous limestone, anthracitous micaslate, anhydre gypsum, and grauwacke; b) clayslate, black-limestone, grauwacke with greenstone, syenites, transition-granite, and porphyries with a base of compact feldspar; c) euphotides, sometimes pure and covered with jaspar, sometimes mixed with amphibole, hyperstein, and grey limestone; d) pyroxenic porphyries with amygdaloides and, zirconien syenites. 3, *Secondary soil*, beginning by a great destruction of monocotyledon plants. a) co-ordinate and almost contemporary formations with red sandstone (*rothes totes tiegende*), quarzier porphyry, and fern-coal. These beds are less connected by alternance than by opposition. The porphyries issue (like the trachytes of the Andes), in domes from the bosom of intermediary rocks. Porphyrific brechias, which envelope the quarzifere porphyries. b) Zechstein or Alpine limestone, with marno-bituminous slate, fetid limestone, and variegated gypsum; Productus aculeatus. c) variegated sandstone (*bunte sandstein*) with frequent beds of limestone; false oolithes;

where the formations of granite and gneiss, are extremely distinct; there are others, on the contrary, where the geognostic limits between those formations are little marked, and where granite, gneiss, and micaslate appear to alter-

the upper beds are of variegated marl, often muriatiferous (*red marl, salzthon*), with hydrated gypsum and fetid limestone. The gemsalt oscillates from zechstein to muschelkalk. d) limestone of Gottingen or muschelkalk, alternating towards the top with white sandstone or quadersandstein; (Ammonites nodosus, encrines, Mytilus socialis) clayey marl is found at the two extremities of muschelkalk. e.) while sandstone, quadersandstein, alternative with lias, or limestone a gryphees; a quantity of dicotyledons mixed with monocotyledon plants. f.) jura limestone, complex formation; a quantity of arenacious intercalated marl. We most frequently observe from below to above; lias (marnous limestone with gryphites), oolithes, limestone with polypiers, slaty limestone with fish, and crustaices, and hydrated globular iron. Amonites planulatus, Ghryphæa arcuata. g.) secondary sandstone with lignites, iron sand, weald clay, green sand, or green-sandstone. h.) chlorite, tufted, and white chalk; (planerkalk, limestone of Verona). IV. *Tertiary soil*, beginning by a great destruction of decotyledon plants. a.) clay and tertiary sandstone with lignites; plastic clay; mollass, and nagelfluhe, sometimes alternating where chalk is wanting; with the last beds of Jura limestone; succin. b.) limestone of Paris or coarse limestone, limestone with circles; limestone of Bolca, limestone of London, arenacious limestone of Bognor; lignites. c.) silicious limestone, and gypsum with bones alternating with marl. d.) sandstone of Fontainebleau. e.) lacustre soil with porous meulieres. e.) alluvial deposits.

nate by layers, or pass often from one to the other*. These alternations, and these passages, appeared to me less common in the Cordillera of the shore of Venezuela than in the Sierra Parime. We recognise successively, in the former of these two systems of mountains, above all, in the chain nearest the coast, as predominating rocks from west to east, granite (long. 70°—71°) gneiss, (long. 68½°—70°), and micaslate (long. 65½° 66½°); but considering in mass the geognostic constitution of the shore, and the Sierra Parime, we prefer to treat of granite, gneiss, and micaslate, if not as one formation, at least, as three co-ordinate formations strictly linked together †. The clayey primitive slate (*urthonchiefer*), is subordinate to micaslate, of which it is only a modification. It no more forms an *independant soil* in the New Continent, than in the Pyrenees and the Alps.

α. GRANITE which does not pass to gneiss is the most common in the western part of the chain of the shore, between Turmero, Valencia, and Porto Cabello, as well as in the circle of the Sierra Parime, near the Encaramada, and at the Peak of Duida. At Rincon del Diablo (Vol. iv. p. 167) between Mariara and Hacienda

* See my *Essay on the position of rocks in the two hemispheres*, p. 67, 69, 71, 74, 76.

† See above, Vol. iv, p. 277; Vol. v, p. 857, 858.

de Cura, and at Chuao (Vol. iv. p. 116, 167), it has large grains, containing fine crystals of feldspar, 1½ inches long. It is divided in prisms by perpendicular vents, or stratified regularly, like secondary limestone, at las Trincheras (Vol. iv, p. 198); the strait of Baraguan in the valley of the Oroonoko, (Vol. iv, p. 502), and near Guapasoso, on the banks of the Atabapo (Vol. v, p. 224). The stratified granite of the Trincheras, giving birth to very hot springs (from 90·3° cent.), appears from the inclination of its layers, superposed upon gneiss, which is seen further southward in the islands of the lakes of Valencia; but conjectures of superposition founded only on the hypothesis of an indefinite prolongation of the strata, are little certain; and perhaps the granite masses which form a small particular zone in the northern range of the Cordillera of the shore, between 70° 3′, and 70° 50′ of longitude * were heaved-up in piercing the gneiss. The latter rock is prevalent, both in descending from the Rincon del Diablo towards the south, to the hot-springs of Mariara, and towards the banks of the lake of Valencia, and in advancing on the east towards the groupe of Buenavista, and the Silla of Caraccas, and Cape Codera. In the region of

* In supposing Nueva Valencia long. 70° 34′, and Villa de Curalong, 70° 5′.

the chain of the shore of Venezuela, where granite seems to constitute an independent formation from 15 to 16 leagues in length, I saw no *foreign or subordinate layers* of gneiss, mica-slate, or primitive limestone *.

The Sierra Parime is one of the most extensive granitic soils existing on the globe †; but the granite which is seen alike bare on the flank of the mountains, and in the plains by which they are joined, often passes to gneiss. (Vol. iv, p. 552.) Granite is most commonly found in its granular composition, and independent formation, near the Encaramada (Vol. iv, p. 462), at the strait of Baraguan, (Vol. iv, p. 502), and in the vicinity of the mission of the Esmeralda. It often contains, like the granites of the Rocky Mountains (lat. 38°—40°), the Pyrenees, and Southern Tyrol, amphibol crystals ‡, disseminated in the mass,

* Primitive limestone, every where so common in mica-slate and gneiss, is found in the granite of the Pyrenees, at port d'Oô; and in the mountains of Labourd, (*Charpentier, sur la const. geogn. des Pyrenees*, p. 144, 146.

† *See* above, Vol. vi, p. 501—520. To prove the extent of the continuity of this granitic soil, it will suffice to observe that M. Lechenault de la Tour, collected in the bars of the river Mana, in French Guyana, the same gneiss granites (with a little amphibol) which I observed three hundred leagues more to the west, near the confluence of the Orconoko and the Guaviare.

‡ I did not observe this mixture of amphibol in the gra-

but without passing to syenite (Vol. v, p. 18, 435). Those modifications are observed on the banks of the Oroonoko, the Cassiquiare, the Atabapo, and the Tuamini. The blocks heaped together which are found in Europe on the ridge of granitic mountains (Riesengebirge in Silesia, Ochsenkopf in Franconia), are above all remarkable in the north-west part of the Sierra Parime, between Caycara, the Encaramada, and Uruana, in the cataracts of the Maypures and at the mouth of the Rio Vichada (Vol. v, p. 177). It remains doubtful if these heaved-up masses, of cylindric form (Vol. iv, p. 540), parallelipedes rounded on the edge, or balls of 40 to 50 feet in diameter (Vol. v, p. 616, &c.), are the effect of a slow decomposition, or of a violent and instantaneous heaving-up. The granite of the south-east part of Sierra Parime sometimes passes to *pegmatite* *, composed of laminary feldspar, enclosed in curved masses of crystalline quartz. I saw gneiss only in *subordinate layers* †; but, between Javita, San Car-

nite of the chain of the coast of Venezuela, unless at the summit of the Silla de Caraccas (Vol. iii, p. 505).

* *Schrift-granit.* It is a simple modification of the composition and texture of granite, not even a subordinate layer. It must not be confounded with the real pegmatite, generally destitute of mica, or with the *geographic stones* (*piedras mapajas*) of the Oroonoko (Vol. v, p. 559), which contain streaks of dark green mica variously turned.

† The magnetic sands of the rivers that furrow the gra-

los del Rio Negro, and the Peak of Duida, the granite is traversed by numerous veins of different ages (Vol. v, p. 401), spread over with rock-crystal, black tourmaline, and pyrites (Vol. v, p. 229, 506). It appears that these open veins become more common on the east of the Peak of Duida, in the Sierra Pacaraina, above all between Xurumu, and Rupunuri (tributary streams of the Rio Branco, and the Essequibo), where Hortsman the traveller, discovered instead of diamonds * and emeralds, a mine, or oven of rock-crystal (Vol. v, p. 792; Vol. vi, p. 518).

β. GNEISS predominates along the Cordillera of the shore of Venezuela with the appearances of an independant formation in the northern

nitic chain of the Encaramada (Vol. vi, p. 502), seem to denote the proximity of amphibolic or chloritic slate (*hornblend or chlorit schiefer*), either in layers in the granite, or superposed on that rock (Vol. v, p. 678).

* These fables of *diamonds* are very ancient on the coast of Paria. Petrus Martyr relates, that at the beginning of the sixteenth century, a Spaniard, Andrès Morales, bought of a young Indian of the coast of Paria "*adamantem mire pretiosum, duos infantis digiti articulos longum, magni autem pollicis articulum æquantem crassitudine, acutum utrobique et costis* 8 *pulchre formatis constantem.*" This pretended *adamas juvenis pariensis* resisted the lime. Petrus Martyr distinguishes it from topazes by adding, "offenderunt et topazios in littore," that is, on the coast of Paria, Saint Martha, and Veragua. See *Oceanica*, Dec. iii, lib. iv, p. 53.

chain, from Cerro del Chuao, and the meridian of Choroni, as far as Cape Codera; and in the southern chain, from the meridian of Guigue, to the mouth of the Rio Tuy. Cape Codera, (Vol. iii, p. 375), the great mass of the Silla, of Galipano, and the land between Guayra and Caraccas (Vol. iii, p. 417, 520, 527, 528, 532), the table-land of Buenavista (Vol. iv, p. 74), the islands of the lake of Valencia (Vol. iv, p. 161, 168, 177), the mountains between Guigue, Maria Magdalena, and the Cerro de Chacao (Vol. ii, p. 273, 277), are composed of gneiss *; yet amidst this soil of gneiss, inclosed micaslate reappears, often talquous in the Valle de Caurimare, and in the ancient Provincia of los Mariches (Vol. iii, p. 531); at Cabo Blanco, west of la Guayra (Vol. iii, p. 402); near Caraccas and Antimano (Vol. iv, p. 59, 60), and above all, between the table-land of Buenavista, and the vallies of Aragua, in the mountain of the Cocuyzas and at Hacienda del Tuy (Vol. iv, p. 78, 91). Between the limits which we have here assigned to gneiss, as a predominant rock (long. 68½°—70½°), gneiss passes sometimes to mica-

* I have been assured that the islets Orchila and Los Frailes are also composed of gneiss. Curaçao and Bonaire are calcareous. Is the island of Oruba, in which *pepites* of native gold of a considerable size have lately been found, primitive?

slate, while the appearance of a passage to granite is only found on the summit of the Silla de Caraccas * (Vol. iii, p. 508); it would still require to be examined with more care than I was able to do, whether the granite of the top of Saint Gothard, and of the Silla of Caraccas, reposes effectively on micaslate and gneiss, or if it has merely *pierced* those rocks rising in the form of needles, or domes. The gneiss of the Cordillera of the shore, in the province of Caraccas, contains almost exclusively garnets, rutile, titanite and graphite, disseminated in the whole mass of the rock (Vol. iii, p. 417, 418); shelves of granular limestone (*ib.*) and some metalliferous veins (Vol. iii, p. 525, 532; Vol. iv, p. 269). I shall not decide whether the grenatiferous *serpentine* of the table-land of Buenavista be inclosed in gneiss, or whether, superposed upon that rock, it do not rather belong to a formation of *weisstein* (heptinite) similar to that of Penig and Mittweyde in Saxony (Vol. iv, p. 79, 92).

In that part of the Sierra Parime which M. Bonpland and myself visited, gneiss forms a less marked zone, and *oscillates* more frequently towards granite than micaslate. I found no garnets in the gneiss of Parime. There is no

* The Silla is a mountain of gneiss like Adam's Peak (in the island of Ceylon), and of nearly the same height.

doubt that the gneiss-granite of the Oroonoko is a little auriferous on some points (Vol. iv, p. 471 ; Vol. v, p. 678, 857 ; Vol. vi, p. 215).

γ. *Micaslate* forms with clayslate (*thonschiefer*), a continued soil in the northern chain of the Cordillera of the shore, from the point of Araya, beyond the meridian of Cariaco, as well as in the island of Marguerita. It contains, in the peninsula of Araya, garnets disseminated in the mass, cyanite (Vol. ii, p. 285), and when it passes to clayey-slate, small layers of native alum (Vol. vi, p. 93, 99, 102). Micaslate constituting an independant formation, must be distinguished from micaslate subordinate to a soil of gneiss, on the east of Cape Coderà. The micaslate subordinate to gneiss, displays in the valley of Tuy, shelves of primitive limestone (Vol. iii, p. 92), and small layers of graphic ampelite (*zeicheschiefer*) ; between Cape Blanc and Catia, layers of chloritic, granatiferous slate, and slaty amphibol (Vol. iii, p. 404) ; and between Caraccas and Antimano, the more remarkable phenomenon of veins of gneiss inclosing balls of granatiferous diorite * (*grunstein*) (Vol. iv, p. 59, 60).

In the Sierra Parime, micaslate predominates only in the most eastern part, where its lustre has given rise to strange errors (Vol. v, p. 838,

* See my geognostic Essay, p. 337.

857). The *amphibolic slate* of Angostura (Vol. v, p. 699), and masses of *diorite* in balls, with concentric layers, near Muitaco (Vol. v, p. 691), appear to be superposed, not on micaslate, but immediately on gneiss-granite. I could not, however, distinctly ascertain whether a part of this pyritous diorite was not inclosed on the banks of the Oroonoko, as it is at the bottom of the sea near Cabo Blanco (Vol. iii, p. 405), and at the Montaña de Avila, in the rock that it covers. Very large veins, with an irregular direction, often assume the aspect of *short layers*; and the balls of *diorite* heaped together in hills, may well, according to the analogy of so many cones of basalt, have issued from the crevices.

Micaslate, chloritic slate, and the rocks of slaty amphibol, contain magnetic sand in the tropical regions of Venezuela, as in the most northern regions of Europe. The garnets are there almost equally disseminated in the gneiss (Caraccas), the micaslate (peninsula of Araya), the serpentine (Buenavista), the chloritic slate (Cabo Blanco), and the diorite or greenstone (Antimano): we shall see further on, that these garnets re-appear in the trachytic prophyries that crown the celebrated metalliferous mountain of Potosi, and in the black and pyroxenic masses of the small volcano of Yana-Urcu, at the back of Chimborazo.

The petroleum, and this phenomenon is well worthy of attention, issues from a soil of micaslate in the gulph of Cariaco (Vol. ii, p. 290). If, further east, on the banks of the Arco (Vol. iii, p. 97; Vol. iv, p. 51), and near Cariaco (Vol. ii, p. 216, 290), it seems to gush from secondary limestone formations, it is probably only because those formations repose on micaslate (Vol. vi, p. 97). The hot springs of Venezuela have also their origin in, or rather below, the primitive rocks. They issue from granite (Las Trincheras), gneiss (Mariara and Onoto), and the calcareous and arenacious rocks that cover the primitive rocks (Morros de S. Juan, Bergantin, Cariaco). The earthquakes and subterraneous detonations, of which the seat has been erroneously sought in the calcareous mountains of Cumana, have been felt with most violence in the granitic soils of Caraccas, and the Oroonoko (Vol. iv, p. 24, 45). Igneous phenomena (if their existence be really well certified), are attributed by the people to the granitic peaks of Duida and Guaraco, and also to the calcareous mountain of Cuchivano (Vol. iii, p. 83; Vol. v, p. 550, 551).

From the whole of these observations, it results, that gneiss-granite predominates in the immense groupe of the mountains of Parime, as micaslate-gneiss does in the Cordillera of the shore; that in the two systems, the granitic

soil, unmixed with gneiss and micaslate, occupies but a very small extent of country; and that in the chain of the shore, the formations of clayey slate (*thonschiefer*), micaslate, gneiss, and granite, succeed each other in such a manner on the same band from east to west (presenting a very uniform and regular inclination of their strata towards the north-west), that according to the hypothesis of a subterraneous prolongation of the strata, the granite of las Trincheras and the Rincon del Diablo, may be superposed on the gneiss of the Villa de Cura, of Buenavista, and Caraccas; and the gneiss superposed in its turn, on the micaslate and clayslate of Maniquarez and Chuparuparu in the peninsula of Araya. I have already observed in another place, that this hypothesis of a prolongation of every rock, in some sort indefinite, founded on the angle of inclination which the strata present on the surface of the soil, is not admissible, and that according to similar and equally vague reasoning, we should be forced to consider the primitive rocks of the Alps of Switzerland as superposed on the formation of the compact limestone of Achsenberg, and that limestone (of transition, or identic with zechstein?) as being superposed on the mollassus of tertiary soil.

II. FORMATION OF CLAYEY-SLATE (THONSCHIEFER) OF MALPASSO.

If, in the sketch of the formations of Venezuela, I had followed the received division into primitive, intermediary, secondary, and tertiary soils, I might be doubtful what place the last layer of micaslate should occupy in the peninsula of Araya. This layer, in the ravine (Aroyo) of Robalo, passes insensibly in a carburated and shining slate, into a real ampelite. The direction and inclination of the strata remain the same, and the *thonschiefer*, which takes the aspect of a *transition-rock*, is but a modification of the primitive micaslate of Maniquarez, containing garnets, cyanite, and rutile titanite (Vol. vi, p. 101, 102). These insensible passages from primitive, to transition soil, by clayey slate that becomes carburated, at the same time that it presents a *concordant position* with micaslate and gneiss, have also been observed several times in Europe * by celebrated geognosts. The existence of an independent formation of *primitive slate* (*urthonschiefer*), may even be doubted, that is, of a formation which

* See the excellent work of M. de Oeynhausen, *Versuch einer géogn. Beschreib. von Oberschlesien*, 1822, p. 57, 62, 415.

is not linked below by layers containing some vestiges of monocotyledon plants.

The small *thonschiefer* bed of Malpasso (in the southern chain of the Cordillera of the shore), is separated from micaslate-gneiss by a co-ordinate formation of serpentine and diorite. It is divided into two shelves, of which the upper presents green steatitous slate, mixed with amphibol; and the lower, dark-blue slate, extremely fissile, and traversed by numerous veins of quartz (Vol. iv, p. 281). I could discover no fragmentary layer (*grauwacke*), nor *kieselschiefer*, nor chiastolithe. The *kieselschiefer* belongs in those countries to a limestone formation, which we shall soon describe; I have seen fine specimens of the chiastolithe (macle) which the Indians wore as amulets, and which came from the Sierra Nevada de Merida. This substance is probably found in transition-slate, for MM. Rivero and Boussingault observed rocks of clay-slate at the height of 2120 toises, in the Paramo of Mucuchies, in going from Truxillo to Merida *.

* In Galicia, in Spain, I saw the *thonschiefer* alternate, which contains chiastholite with *grauwacke*; but the chiastholite belongs indubitably also to rocks which all geognosts have hitherto named primitive rocks, to mica-schistes intercalated like layers in the granite, and to a soil of independent micaslate (*Charpentier*, p. 143, 193).

III. FORMATION OF SERPENTINE AND DIORITE (GREENSTONE OF JUNCALITO).

We have indicated above, a layer of granatiferous serpentine inclosed in the gneiss of Buenavista, or perhaps superposed on that rock; we here find a real soil of serpentine, alternating with diorite, and extending from the ravine of Tucutunemo as far as Juncalito. The diorite forms the great mass of this soil; it is of a dark-green colour, granular with small grains, and destitute of quartz; its mass is formed of small crystals of feldspar, intermixed with crystals of amphibol. This rock of diorite is covered at its surface, by the effect of decomposition, with a yellowish crust like that of basalts, and dolerites. *Serpentine* of a dull olive-green, and smooth fracture, mixed with blueish steatite, and amphibol, presents, like almost all the *co-ordinate formations of diorite and serpentine* (in Silesia, at Fichtelgelirge, in the valley of Baigorry, in the Pyrenees, in the isle of Cyprus, and in the copper mountains of circumpolar America)*, traces of copper (Vol. iv, p. 279). Where the diorite, partly globular, draws near the green slate of Malpasso, real beds of green slate are found inclosed in diorite.

* Franklin's Journal to the Polar Sea, p. 529.

The fine saussurite which we saw in the Upper Oroonoko in the hands of the Indians, seems to indicate the existence of a soil of euphotide, superposed on gneiss-granite, or the amphibolic slate of the eastern part of Sierra Parime. (Vol. v, p. 383, 384, 563, &c.).

IV. GRANULAR AND MICACEOUS LIMESTONE OF THE MORROS OF SAN JUAN.

The Morros of San Juan rise in a soil of diorite, like towers in ruin. They are formed of a cavernous greyish green limestone, of crystalline texture, mixed with some spangles of mica, and destitute of shells. We recognize in them masses of hardened clay, black, fissile, charged with iron, and covered with a crust, yellow from decomposition, like basalts and amphibolites. A compact limestone containing vestiges of shells, is joined to this granular limestone of the Morros of San Juan, which is hollow within (Vol. iv, p. 279; Vol. vi, p. 583). It is probable that in further examining the extraordinary soil, between Villa de Cura and Ordiz, in which I could only collect specimens of rock during one day, many phenomena may be discovered analogous to those which M. Leopold de Buch has lately described in South Tyrol *.

* *Tyroler Bothe vem 26 ten Julius*, 1822; and Geognostic Letter of M. de Buch to M. de Humboldt, 1823, p. 13.

M. Boussingault, in a very instructive memoir which he has recently addressed to me, calls the rock of the Morros a "problematic calcariferous gneiss." This expression seems to prove that the plates of mica take in some parts an uniform direction, as in the greenish dolomie of Val Toccia.

V. FELSPATHIC SANDSTONE OF THE OROONOKO.

The soil of gneiss-granite of the Sierra Parime is covered by fragments, (between the Encaramada and the strait of Baraguan, and in the Island of Guachaco), in its western part, of an olive-brown sandstone, containing grains of quartz, and fragments of feldspar, joined by a clayey-cement, extremely compact. This cement, where it abounds, has a conchoid fracture, and passes to jasper. It is crossed by small veins of brown iron-ore, which separate into very thin plates, or blades. (Vol. iv, p. 573.) The presence of feldspar seems to indicate that this small formation of sandstone (the sole secondary formation hitherto known in the Sierra Parime), belongs to red-sandstone or coal *. I have hesitated to join it to the *sand-*

* Broken or intact crystals of feldspar are found in the *tote liegende*; or coal sandstone of Thuringia (*Freiesleben geogn. Arbeiten*, Vol. iv, p. 82, 85, 96, 194). I observed in

stone of the Llanos, of which the relative antiquity has appeared to me to be less verified.

VI. FORMATION OF THE SANDSTONE OF THE LLANOS OF CALABOZO.

I place the formations in the successive order which I thought I perceived from my first impressions on the spot. The carburated slate or thonschiefer of the peninsula of Araya connect the primitive rocks of gneiss-granite, and mica-slate gneiss, with the transition soil (blue and green slate, diorite, and serpentine mixed with amphibol, granular greenish-grey limestone) of Molpasso, Tucutunemo, and San Juan. Towards the south, the *sandstone of the Llanos* rests on this transition-soil; it is destitute of shells, and composed (savannahs of Calabozo) of rounded fragments of quartz *, kieselschiefer and lydian,

Mexico a very singular agglomerated feldspathic formation, superposed upon, perhaps inclosed in, red sandstone, near Guanaxuato. *See* my *Political Essay*, Vol. ii, p. 179, 180; and my work on the *position of rocks*, p. 2 8.

* In Germany, sandstones which belong indubitably to red sandstone, contain also (near Weiderstadt, in Thuringia) galets, and rounded fragments (*Friesleben*, Vol. iv, p. 77). They have on that account been designated by the name of *nagelfluhe* (Meinicke, in the *Naturforscher*, St. 17, p. 48). I shall not cite the pudding-stones subordinate to the red sandstone of the Pyrenees, because the age of that sandstone, destitute of coal, may be contested (*Charpentier*, p.

cemented by a ferruginous, olive-brown clay. (Vol. iv, p. 384, 385.) We there find fragments of wood, in great part monocotyledon, and masses of brown iron. Some layers (Mesa de Paja) present grains of very fine quartz; I saw no fragments of porphyry, or limestone. Those immense beds of sandstone that cover the Llanos of the Lower Oroonoko and the Amazon, merit the greatest attention of travellers. By their aspect they draw near the nagelfluhes or pudding-stones of the molassus soil, in which calcareous vestiges are also often wanting, (Schottwyl and Diesbach, in Switzerland *); but they appeared to me by their position to have rather a relation to *red sandstone*. They can no where be confounded with the grauwackes (fragmentary transition-rocks) which MM. Boussingault and Rivero † found along

427). Layers of very fine rounded gneiss of quartz are inclosed in the *tote liegende* of Thuringia, (*Freiesleben*, Vol. iv, p. 97) and in Upper Silesia (*Ocyhaussen*, *Besch. von Oberschlesien*, p. 119).

* *Meisner*, *Annalen der allgem. schweiz. Gesellschaft*, P. I. p. 49.

† Those travellers not only levelled their route by means of the barometer, but also determined the position of a great number of points by meridian observations of the Sun and Canopus, and by the use of a time-keeper. I shall here transcribe some latitudes that are very uncertain on our maps: Maracay, 10° 15′ 58″; San Carlos, 9° 40′ 10″; Barquisimeto, 9° 54′ 35″; Tocuyo, 9° 15′ 51″; Truxillo,

the Cordilleras of New Grenada, bordering the steppes on the west. Does the want of fragments of granite, gneiss, and porphyry, and the frequency of petrified wood *, sometimes dicotyledons, indicate that those sandstones belong to more recent formations, which fill the plains between the Cordilleras of Parime and the shore, as the molassus of Switzerland fills the space between the Jura and the Alps? I dis-

8° 59′ 36″; Pamplona, 7° 17′ 3″. The following are the names of the towns which MM. Boussingault, Rivero, and myself have observed at different epochas, but not always in the same settlements. The first latitude is that which I have published; the second, that of the two travellers I have just named; Caraccas, 10° 30′ 50″; 10° 30′ 58″; Valencia, 10° 9′ 56″; 10° 10′ 34″: Villa de Cura, 10° 2′ 47″; 10° 3′ 44″; S. Juan de los Morros, 9° 55′ 0″; 9° 55′ 50″: Honda, 5° 11′ 45″; 5° 11′ 20″: M. Boussingault estimates the latitude of Merida 8° 16′ 0″.

* The people attribute those woods to Bowdichia virgilioïdes or Alcornoco, (See my *Nova Gen. and Spec.* Vol. iii, p. 377), and to Chapara Bovo (Rhopala complicata). It is believed in Venezuela, as in Egypt, that petrified wood is formed in our times. I shall here observe that I found this dicotyledon petrified wood only at the surface of the soil, and not inclosed in the sandstone of the Llanos. M. Caillaud made the same observation in going to the Oasis of Siwa. The trunks of trees 90 feet long, inclosed in the red sandstone of Kifhauser (in Saxony), are, according to the recent researches of M. de Buch, divided into knots, and are certainly monocotyledons.

cussed this problem in another work *; but the materials hitherto collected are too incomplete. It is not easy, when several formations are not yet developed, to pronounce on the age of arenacious rocks. Even in Germany, the classic soil of geognosy, the most able observers are not agreed on the sandstone of the Black Forest, and of the whole country south-west of Thuringer-Waldgebirge. M. Boussingault, who passed through a part of the steppes of Venezuela long after me, is of opinion that the *sandstone* of the *Llanos* of San Carlos, that of the valley of San Antonio of Cucuta, and the tablelands of Barquisimeto, Tocuyo, Merida, and Truxillo, belong to a formation of *antient red sandstone*, or coal. There is in fact real coal near Carache, south-west of Paramo de las Rosas.

Before a part of the immense plains of America was geognostically examined, it might have been supposed that their uniform and continued *horizontality*, was owing to alluvial soils, or at least to arenacious tertiary soils. The sands which in the *country of the Baltic*, and in all the north of Germany cover coarse limestone and chalk, seem to justify these systematic ideas, which have not failed to be ex-

* *Sur le gisement des roches dans les deux hémisphères*, p. 230.

tended to the Sahara, and the steppes of Asia. But the observations which we have been able to collect, suffice to prove that in both worlds, the plains, the steppes, and the desarts, contain a great number of formations of different ages, and that those formations often appear without being covered by alluvial deposits. The Jura-limestone, gem-salt, (plains of the Meta and Patagonia) and coal sandstone, are found in the Llanos of South America; the quadersandstone * (desart between the Arkansas, and the Canadian river; River Plata), a saliferous soil, beds of coal †, (declivity of the Alleghanies, banks of the Ohio), and limestone with ‡ trilo-

* Long. Expedition, Vol. ii, p. 293. The physiognomy of these rocks cut in walls and pyramids, or divided in *rhomboid* blocks, seems no doubt to characterize the quadersandstone; but the sandstone of the eastern declivity of the Rocky Mountains, in which the learned traveller Mr. James, found salt-springs (*licks*), layers of gypsum, and no coal, (*L. c.* Vol. ii, p. 397, 404,) appear rather to belong to variegated sandstone (*bunte sandstein*).

† *L. c.* Vol. i, p. 15. This coal immediately covers, as in Belgium, the grauwacke, or transition-sandstone.

‡ *L. c.*, Vol. i, p. 147. In the plains of the Upper Missoury the limestone is immediately covered by a secondary limestone with *turritulles*, believed to be jurassic, while a limestone with gryphees, rich in lead-ore, and which I should have believed to be still more antient than oolithic limestone and analogous to *lias*, is, according to Mr. James, (*L. c.*, Vol. ii, p. 412,) placed above the most recent formation of sandstone. Has this superposition been well ascertained?

bites (Missoury above Council Bluff), fill the vast plains of Louisiana and Canada. In examining the rocks which the indefatigable Caillaud has collected in the Lybian desart, and in the Oasis of Siwa, we recognize sandstone similar to that of Thebes; fragments of petrified dicotyledon wood (from 30 to 40 feet long), with rudiments of branches and medullary concentric layers, coming perhaps from tertiary sandstone with lignites*; chalk, with *spatanges* and anachytes, limestone (jurassic) with nummulites partly agatized; another limestone with small grains† employed in the construction of the temple of Jupiter Ammon (Omm-Beydah); and gemsalt with sulphur and bitumen‡. These examples sufficiently prove that the plains, *(Llanos,)* steppes, and desarts, have not that uniformity of tertiary rocks which has been too generally supposed. Do the fine pieces of ribboned-jasper, or *pebbles* of Egypt, which M. Bonpland picked up in the

* Formation of molassus.

† M. de Buch justly enquires if this statuary limestone, which resembles the marble of Paros, and limestone become granular by its contact with the systematic granite of Predazzo, is a modification of the limestone with nummulites of Siwa? The primitive mountains from which the marble with small grains was believed to be extracted, if there is no deception in its granular appearance, are far distant from the Oasis of Siwa.

‡ *Caillaud et Drovetti, Voyage à Syouah*, p. 8, 9, 16.

savannahs of Barcelona (near Curataquiche), belong to the sandstone of the Llanos of Calabozo, or to a soil superposed on that sandstone? The former of these suppositions would approach, according to the analogy of the observations made by M. Roziere in Egypt, other sandstone of Calabozo of tertiary *nagelfluhe* (Vol. vi, p. 49).

VII. FORMATION OF COMPACT LIMESTONE OF CUMANACOA.

A blueish-grey compact limestone, almost destitute of petrifactions, often crossed by small veins of carburated lime, forms mountains with very abrupt ridges. These layers have the same direction and the same inclination (Punta Delgada, on the east of Cumana) as the mica-slate of Araya. Where the flank of the limestone mountains of New Andalusia is very steep, we observe, as at Achsenberg, near Altorf, in Switzerland, layers that are singularly arched or turned. The tints of the limestone of Cumanacoa vary from darkish-grey to bluish-white (Bordones; centre of Cerro del Impossible; Cocollar; Turimiquiri; Montaña de Santa-Maria), and sometimes pass from compact to granular. (Vol. ii, p. 263; iii, p. 11, 76, 80, 94, 175.) It contains, as *substances accidentally disseminated* in the mass, brown-

iron-ore, spathic iron, (Vol. iv, p. 384,) and even rock-crystal*; and as subordinate layers, 1st. numerous strata of carburated and slaty marl, with pyrites (Cerro del Cuchivano, near Cumanacoa); 2d. quartzous sandstone, alternating with very thin strata of clayey slate. (Quetepe, south of Cumana; Cerro del Impossible; table-land of Cocollar; Cerro de Saca Manteca, near Catuaro, probably also the basin of Guarda de San Agustin, and the Purgatorio). This sandstone contains springs. In general it only covers the limestone of Cumanacoa, but it appeared to me to be sometimes inclosed (Vol. iii, p. 11, 23, 94, 181); 3d. gypsum with sulphur, near Guire, in the Golfo Triste, on the coast of Paria (Vol. iv, p. 386). As I did not examine on the spot the position of this yellowish-white gypsum with small grains, I cannot pronounce with certainty on its *relative age*. The only petrifactions of shells which I found in this limestone formation, are a heap of turbinites and trochites on the flank of Turimiquiri, at more than 680 toises high, and an ammonite seven inches in diameter, in the *Montaña de Santa Maria*, north north-west of Caripe. I no where saw the *limestone of Cumanacoa*, of which I treat specially in this ar-

* The zechstein of Gross-Oenner in Thuringia, also incloses rock-crystal. *Freiesleben*, Vol. iii, p. 17.

ticle, repose on the *sandstone of the Llanos*; if this superposition takes place, it must be found in descending the table-land of Cocollar towards the Mesa of Amana. On the southern coast of the gulph of Cariaco, the limestone formation (Punta Delgada), probably covers, without the interposition of another rock, the micaslate that passes to carburated clayslate. In the northern part of the gulph I saw distinctly this clayey formation at the depth of two or three fathoms in the sea. The sub-marine hot-springs (Vol. iii, p. 199) appeared to me to gush from micaslate, like the petroleum of Maniquarez (Vol. ii, p. 290). If any doubts remain as to the rock on which the *limestone of Cumanacoa* is immediately superposed, there is none respecting the rocks which cover it, such as 1st. the tertiary limestone of Cumana, near Punta Delgada, and at Cerro de Meapire (Vol. iii, p. 181); 2d. the sandstone of Quetepe and Turimiquiri, which forming layers also in the limestone of Cumanacao, belongs properly to the latter soil; the limestone of Caripe, which we have often identified, in the course of this work, with jurassic limestone, and of which we shall speak in the following article.

VIII. FORMATION OF COMPACT LIMESTONE OF CARIPE.

In descending the Cuchilla of Guanaguana towards the convent of Caripe, we find another

more recent formation, white, with smooth fracture, or imperfectly conchoid, and divided in very thin layers, which (Vol. iii, p. 107,) succeeds to the *bluish-grey limestone formation of Cumanacoa.* I call this in the first instance the *limestone formation of Caripe*, on account of the cavern of that name which is inhabited by thousands of nocturnal birds. This limestone appeared to me identical, 1st. with the limestone of Morro de Barcelona, and the Chimanas Islands (Vol. iii, p. 365; Vol. vi, p. 80) which contains small layers of black *kieselschiefer*, (slaty jasper,) destitute of veins of quartz, and breaking into fragments of parallelopid form; 2d. with whitish-grey limestone, with smooth fracture of Tisnao, which seems to cover the sandstone of the Llanos (Vol. iv, p. 386). We find the *formation of Caripe* in the Island of Cuba (between the Havannah and Batabano, and between the port of Trinidad and Rio Guaurabo), as in the islets of the Caymans.

I have hitherto described the secondary limestone-formations of the chain of the shore, without giving them the *systematic names* which may connect them with the formations of Europe. During my stay in America, I took the *limestone of Cumanacoa* for *zechstein*, or *alpine limestone*, and that of *Caripe* for *jurassic limestone*. The carburated and slightly bituminous marl of Cumanacoa, analogous to the

layers of bituminous slate, which are very numerous * in the Alps of South Bavaria, appeared to me to characterize the former of these formations; while the dazzling whiteness of the cavernous soil of Caripe, and the form of those steps of rocks rising in walls and cornises, brought strongly to my mind the jurassic limestone of Streitberg, in Franconia, or of Oitzow, and Krzessowice, in Upper Silesia. There is a suppression in Venezuela of the different soils, which, in the antient continent, separate zechstein from jura-limestone. The sandstone of Cocollar, which sometimes covers the limestone of Cumanacoa, may be considered as *variegated sandstone*; but it is more probable that in alternating by layers with the limestone of Cumanacoa, it is sometimes repulsed to the upper limit of the formation to which it belongs. The zechstein of Europe also contains very quartzous sandstone †. The two limestone soils of Cumanaco and Caripe succeed each other immediately, like the alpine and jura limestone on the western declivity of the Mexican table-land, between Sopilote, Mescala, and Tehuilotepec. These formations perhaps pass from one to the other, so that the

* I found them also in the Peruvian Andes, near Montau, at 1600 toises high.

† See my *Geogn. Essay*, p. 257.

latter may be only an upper shelf of zechstein. This immediate covering *, this suppression of interposed soils, this simplicity of structure, and absence of oolithic layers, have been equally observed by able geognosts, in Upper Silesia and in the Pyrenees †. On the other hand, the immediate superposition of the limestone of Cumanacoa on mica-slate and transition clayslate, the rarity of the petrifications which have not yet been sufficiently examined, the layers of silex passing to lydian stone, may lead to the belief that the soils of Cumanacoa and Caripe are of a much more antient formation than the *secondary* rocks. We must not be surprised that the doubts of the geognost, when obliged to decide on the relative age of the *limestone of the high mountains* in the Pyrenees, the Appenines (south of the lake of Perugia,) and in the Swiss Alps, extend to the lime-stone soils of the high mountains of New Andalusia, and every where in America where the presence of *red sandstone* is not distinctly recognized.

IX. SANDSTONE OF BERGANTIN.

Between Nueva Barcelona and las Cerro del Bergantin (Vol. vi, p. 162) a quartzous sand-

* *L. c.* p. 281, 291.

† *Cart von Oeyhausen*, p. 258. 450; *Charpentier*, p. 444, 446.

stone covers the (jurassic) limestone of Cumanacoa. Is it an arenacious rock, analogous to *green sandstone*, or does it belong to the sandstone of Cocollar? In the latter case, its presence seems to prove still more clearly, that the limestones of Cumanaco and Caripe are only *two parts of the same system*, alternating with sandstone, sometimes quartzous, sometimes slaty.

X. GYPSUM OF THE LLANOS OF VENEZUELA.

Deposits of lamellar gypsum, containing numerous layers of marl, are found by fragments in the steppes of Caraccas and Barcelona; for instance, in the table-land of San Diego, between Ortiz and *Mesa de Paja*; near the mission of Cachipo. They appeared to me to cover the (jurassic) limestone of Tisnao, which is analagous to that of Caripe, where we find it mixed with masses of fibrous gypsum (Vol. iv, p. 386; Vol. vi, p. 49). I have not given the name of *formations*, either to the *sandstone of the Oroonoko*, or *that of Cocollar*, to the *sandstone of Bergantin*, or the *gypsum of the Llanos*, because nothing hitherto proves the *independence* of those arenacious and gypsous soils. I presume it will one day be ascertained that the gypsum of the *Llanos* covers not only the (jurassic) limestone, of the Llanos, but is

sometimes enclosed in it like the gypsum of Golfo Triste on the east of the (Alpine) limestone of Cumanacoa. Perhaps the great masses of sulphur (Vol. iii, p. 104; Vol. iv, p. 50, 386), found in the layers, almost entirely clayey, of the steppes (Guayuta; valley of San Bonifacio; Buen Pastor; confluence of the Rio Pao with the Oroonoko), belong to the marl of the *gypsum of Ortiz?* These clayey beds are so much more worthy of the attention of travellers, since the fine observations of M. de Buch, and several other celebrated geognosts, on the *cavernosity* of gypsum, the irregularity of the inclination of its strata, and its parallel position with the two declivities of Harz, and the (heaved-up) chain of the Alps, on the simultaneous presence of sulphur, oligist iron *, and the sulphurous acid vapours which preceded the formation of sulphuric acid, seem to manifest the action of forces that reside at a great depth in the interior of the globe †.

* Gypsum with oligist iron in the variegated sandstone, south of Dax (department of the Landes).

† *Leopold von Buch, Resultate geogn. Forsch.*, 1824, p. 471-473. Friedrich Hofmann, *Beitr. zur geogn. Kenntniss von Norddeutschland*, 1822, Vol. i, p. 85, 92. *Boué, Mém. sur les terrains second. du versant nord des Alps*, p. 14. *Freieslaben, Kupferschiefer*, 1809, Vol. ii, p. 124. *Baeislak, Geol.*, Vol. i, p. 255.

XI. FORMATION OF MURIATIFEROUS CLAY (WITH BITUMEN AND LAMELLAR GYPSUM) OF THE PENINSULA OF ARAYA.

This soil presents a striking analogy with *salzthon* or *leberstein* (muriatiferous clay), which I have represented as accompanying gem-salt in every zone *. In the salt-pits of Araya (Haráia), it had attracted the attention of Peter Martyr d'Anghiera, at the beginning of the 16th century (Vol. iii, p. 204). It probably facilitated the rupture of the earth, and the formation of the gulph of Cariaco. The clay is of a smoky colour impregnated with petroleum, mingled with lamellar and lenticulary gypsum, and sometimes traversed by small veins of fibrous gypsum. It incloses angular masses, and less friable, of dark brown clay, with a slaty fracture sometimes conchoid (Vol. ii, p. 266). The muriate of soda is found in parts invisible to the naked eye. The relations of position or superposition of this soil with tertiary rocks does not appear to me sufficiently clear to enable me to pronounce with certainty on this element, the most important of positive geognosy. The *co-ordinate layers of gem-salt, muriatiferous clay, and gypsum,* present the same

* *Humboldt*, Essai géogn., p. 241, *Leonhard*, Characteristik der Felsarten, p. 362.

difficulties in both hemispheres: these masses, of which the forms are very irregular, display traces every where of great commotions. They are scarcely ever covered by *independent formations*; and after having long been believed on the continent of Europe, that gem-salt was exclusively peculiar to alpine and transition limestone, it is now still more generally admitted, either from reasonings founded on analogies, or from suppositions on the prolongation of the layers, that the real position of gem-salt is found * in variegated sandstone (*bunte sandstein*). Sometimes gem-salt appears to oscillate from variegated sandstone towards *muschelkalk*.

I made two excursions on the peninsula of Araya. In the former, I was inclined to consider the muriatiferous clay as subordinate to the agglomerate (evidently of tertiary formation) of Barignon and of the mountain of the castle of Cumana, because a little to the north

* *See Kleinschrod*, in *Leonh. Taschenb.* 1821, Vol. i, p. 148. *Humboldt, Essai geogn.* p. 271. *Hansmann, Jungers Flözgeb.*, p. 177. Perhaps the gem-salt oscillates from variegated sandstone, at the same time towards alpine limestone (zechstein), and towards muschelkalk. An excellent geognist, M. Oeyhausen, places it in the lower layers of muschelkalk. (*Karsten, Archiv.*, 1824, St. 8, p, 11). *See* also MM. de Decker, Oeyhausen, and la Roche in *Hertha*, B. 1, p. 27.

of that castle I had found shelves of hardened clay *, containing lamellar gypsum inclosed, in tertiary soil (Vol. iii, p. 11). I believed that the muriatiferous clay might alternate with the *calcareous agglomerat of Barignon*; and near the fishers' huts situated opposite Macanao, agglomerate rocks appeared to me to pierce the strata of clay. In a second excursion to Maniquarez and the aluminiferous slates of Chaparuparu (Vol. vi, p. 93), the connexion between tertiary soil and bituminous clay, seemed to me somewhat problematical. I examined more particularly the spot of *Peñas negras*, near the Cerro de la Vela, E. S. E. of the ruined castle of Araya. The limestone of the *Peñas* † is compact, of bluish grey, and almost destitute of petrifications. It appeared to me to be much more ancient than the tertiary agglomerate of Barignon, and I saw it covering in concordant position, a slaty clay, somewhat analogous to muriatiferous clay. I had a pleasure in comparing this latter formation with the layers of carburated marl contained in the alpine limestone of Cumanacoa. According to the geognostic ideas that are now the most generally spread, the rock of *Peñas Negras* may be considered as representing the *muschel-*

* Not muriatiferous, and without petroleum ?

† *See* above Per. Nar. Vol. ii, p. 264 to 269.

kalk (limestone of Gottingue), and the saliferous and bituminous clay of Araya as representing *variegated sandstone*; but these problems can only be solved when the mines of those countries are worked. Some geognosts, who believe that the gemsalt of Italy penetrates into a soil above the jura limestone, and even chalks, may be led to take the limestone of *Peñas Negras* for one of the layers of compact limestone, destitute of grains of quartz and petrifications, which we meet with frequently amidst the tertiary agglomerate of Barignon, and of Castillo de Cumana; the saliferous clay of Araya, would appear to them analogous to the *plastic clay of Paris* *, or to the clayey shelves (dief et tourtia) of secondary sandstone with lignites, which contain salt-springs, in Belgium and Westphalia †. However difficult it may be to distinguish *separately* the layers of marl and clay belonging to variegated sandstone, muschelkalk, quadersandstone, jurassic limestone, secondary sandstone with lignites (green and iron sand), and to the tertiary soil above chalk, I believe that the bitumen which every where accompanies gemsalt, and most

* Tertiary sandstone with lignites, or molassus of Argovia.

† Manuscript notes of MM. Dechen and Oeynhausen (*See* also *Buff*, in *Noggerath, Rheinland Westph.* Vol. iii, p. 53).

frequently salt-springs, characterizes the muriatiferous clay of the peninsula of Araya, and the island of Marguerita, as linked with formations placed below the tertiary soil. I do not say that they are *anterior* to that soil, for since the publication of M. de Buch's observations on the Tyrol, it is no longer permitted to consider what is *below*, in space, as necessarily *anterior*, relatively to the epocha of its formation.

The bitumen and petroleum still issue, as we have shewn above (Vol. ii, p. 290; Vol. vi, p. 97), from micaslate; these substances are ejected whenever the soil is shaken by a subterranean force (between Cumana, Cariaco, and the *Golfo Triste*). Now, in the peninsula of Araya, and in the island of Marguerita, saliferous clay impregnated with bitumen is fixed to this primitive soil, nearly in the same manner as gem-salt appears in Calabria by fragments in the basins, inclosed in soils of granite and gneiss *. Do these circumstances serve to support the ingenious system † according to which, all the co-ordinate formations of gypsum, sulphur, bitumen, and gem-salt (con-

* *Melograni, Descr. geologica di Aspromonte,* 1823, p. 256, 276, 287.

† *Breislak, Geologia,* Vol. i, p. 350; *Boué sur les Alpes,* p. 17.

stantly anhydrous) are the effect of overflowings across the crevices which have traversed the oxidated crust of our planet, and penetrated to the seat of volcanic action. The enormous masses of muriate of soda (chlorure de sodium) recently thrown up by Vesuvius *, the small veins of that salt which I have often seen traverse the most recent lithoide lavas, and of which the origin (by sublimation) appears similar to that of oligist iron deposited in the same vents †, the shelves of gem-salt and saliferous clay of the trachytic soil in the plains of Peru, and around the volcano of the Andes of Quito ‡, are well worthy the attention of geologists who would discuss the origin of formations. In the sketch which I here trace, I confine myself to the simple enumeration of the *phenomena of position*, indicating at the same time some theoretic views by which observers placed in more advantageous circumstances than I was myself, may direct their researches.

* Laugier and Gailla, in the *Annales du Mus.*, 5e *année*, No. 12, p. 435. The ejected masses in 1822, were so considerable, that the inhabitants of some villages round Vesuvius, collected them for their domestic use.

† Gay-Lussac, on the action of volcanos, in the *Ann. de chimie*, Vol. xxii, p. 418.

‡ *See* my geogn. Essay, p. 251.

XII. AGGLOMERATE LIMESTONE OF BARIGON, THE CASTLE OF CUMANA, AND THE VICINITY OF PORTO CABELLO.

This is a very complex formation; presenting that mixture and that periodical return of compact limestone, of quarzous sandstone, and of agglomerats (limestone brechia) which peculiarly characterizes, under every zone, the tertiary soil. It forms the mountain of the castle of Saint Antonio, near the town of Cumana, the south-west extremity of the peninsula of Araya, the Cerro Meapire, south of Cariaco, and the vicinity of Porto Cabello (Vol. ii, p. 264, 290; Vol. iii, p. 10, 181, 405; Vol. iv, p. 207; Vol. vi, p. 96). It contains 1° a compact limestone, generally of a whitish grey, or yellowish white (*Cerro de Barigon*), of which some very thin shelves are entirely destitute of petrifications, while others are filled with cardites, ostracites, pectens, and vestiges of lithophyte polypieri: 2° a *brechia* in which an innumerable number of pelagic shells are found mixed with grains of quartz agglutinated by a cement of carbonate of lime; 3° a *calcareous sandstone* with very fine rounded grains of quartz (Punta Arenas, west of the village of Maniquarez), and containing masses of brown iron ore: 4° shelves of marl and slatey clay

destitute of spangles of mica, but inclosing selenite and lamellar gypsum. These shelves of clay appeared to me to form constantly the lower layers. There also belongs to this tertiary soil, the limestone tuf (fresh water formation) of the vallies of Aragua (Vol. iv, p. 109, 186), near Victoria, and the fragmentary rock of Cabo Blanco, at the west of the port of la Guayra. I dare not designate the latter by the name of *nagelfluhe*, because that word indicates rounded fragments, while the fragments of Cabo Blanco are generally angular, and composed of gneiss, hyalin quartz, and chloritous slate, joined by a limestone cement. This cement contains magnetic sand *, madreporites, and vestiges of bivalve pelagic shells. The different fragments of tertiary soil which I found in the Cordillera of the shore of Venezuela, on the two slopes of the northern chain, seem to be superposed near Cumana (between Bordones and Punta Delgada), in the Cerro of Meapire, on the (alpine) limestone of Cumanacoa; between Porto Cabello and the Rio Guayguaza, as well as in the vallies of Aragua, on granite; on the western declivity of the hill formed by the Cabo Blanco, on

* The magnetic sand is no doubt owing to chloritous slate, which, in these latitudes, forms the bottom of the sea. Vol. iii, p. 404; Vol. vi, p. 610.

gneiss; and in the peninsula of Araya, on saliferous clay. This latter mode of position is perhaps but a simple opposition *. If we would range the different members of the tertiary series according to the age of their formation, we ought I believe to regard the *brechia of Cabo Blanco*, with fragments of primitive rocks, as the most ancient, and make it be succeeded by the *arenacious limestone of the castle of Cumana*, destitute of horned silex, yet somewhat analogous to the (coarse) limestone of Paris, and the *fresh water soil of Victoria*. The clayey gypsum, mixed with calcareous brechia with madrepores, cardites, and oysters, which I found between Carthagena and the Cerro de la Popa, and the equally recent limestones of Guadaloupe and Barbadoes †, (limestones filled with pelagic shells resembling those that now exist in the Caribbean sea) prove that the tertiary soil (soil of upper sediment), extends far towards the west and north.

These recent formations, so rich in vestiges of organized bodies, furnish travellers who are

* *An-nicht Auflagerung*, according to the precise language of the geognosts of my country.

† Moreau de Jonnés, *Hist. phys. des Antilles franc.*, Vol. i, p. 564. *Brongniart, Descript. géol. des environs de Paris*, 1822, p. 201.

familiarised with the zoological character of rocks, a vast field of observation. To examine these vestiges in the layers superposed as by steps, the one on the other, is to study the *Faunes of different ages*, and compare them together. The geography of animals traces the limits in space according to the diversity of climates, which determine the actual state of vegetation on our planet. The geology of organised bodies, on the contrary, is a fragment of the *history of nature*, taking the word history in its proper acceptation: it describes the inhabitants of the earth according to the succession of time. We may recognise in museums, kinds and species; but the *Faunes of different ages*, the predominance of certain shells, the numerical relations that characterize the animal kingdom, and the vegetation of a *place*, or of an *epocha*, should be studied in the sight of those formations. It has long appeared to me * that in the tropics as well as in the temperate zone, univalve shells are much more numerous (in their species) than bivalves. From this superiority in number, the *organic fossil world* furnishes, in every latitude, a further analogy with the *intertropical shells* that now live at the bottom of the ocean. In fact, M.

* *Essai geogn.* p. 42.

Defrance, in a work * full of new and ingenious ideas, not only recognizes this preponderance of the univalves in the number of kinds; but also observes, that in 5500 fossil species of univalve, bivalve, and *multivalve* shells, contained in his rich collections, there are 3066 univalve, 2108 bivalve, and 326 *multivalve*†; the univalve fossils are therefore to the bivalve = 3 : 2.

XIII. FORMATION OF PYROXENIC AMYGDALOIDE AND PHONOLITE, BETWEEN ORTIZ AND CERRO DE FLORES.

I place at the end of the formations of Venezuela the pyroxenic amygdaloide soil, and the phonolithic (*porphyrschiefer*), not as being the only rocks which I consider as pyrogenous, but as those of which the entirely volcanic origin is probably posterior to tertiary soil. This result is not owing to the observations I made at the southern declivity of the Cordillera of the shore, between the Morros of San Juan, Parapara, and the Llanos of Calabozo. In that region, local circumstances would rather lead us to regard the amygdaloides of Ortiz as linked to a system of transition rocks (amphibolic serpentine, diorite, and carburated slate

† Table of organised fossil bodies, 1824, p. 51, 125.

of Malpasso) which I described above *; but the irruption of the trachytes across rocks posterior to chalk in the Euganées, and in other parts of Europe, joined to the phenomenon of the total absence of fragments of pyroxenic porphyry, trachyte, basalt, and phonolithe †, in the conglomerats, or fragmentary rocks anterior to the most recent tertiary soils, renders it probable that the appearance of *trapean rocks* at the surface of the soil, is the effect of one of the last revolutions of our planet, even where the irruption has taken place by crevices (veins) which cross the gneiss-granite, or transition rocks, not covered by secondary and tertiary formations.

The small volcanic soil of Ortiz, (lat. 9° 28′ —9° 36′) forms the antient shore of the vast basin of the Llanos of Venezuela; it is composed on the points where I could examine it, of only two kinds of rocks, namely, of amygdaloide and phonolithe (Vol. iv, p. 281, &c.) The greyish blue amygdaloide contains fendilated crystals of pyroxene and mesotype. It forms

* Vol. vi, p. 613.

† The fragments of these rocks appear only in tufs, or agglomerats, which belong essentially to basaltic soil, or surround the most recent volcanos. Every volcanic formation is enveloped in *brechia*, which is the effect of the irruption itself.—*Leopold von Buch, Resultate geogn. Forsch*, p. 311.

balls with concentric layers, of which the flattened centre is nearly as hard as basalt. Neither olivine nor amphibole can be distinguished. Before it appears like an *independent* soil, and rises in small conic hills, the amygdaloide seems to alternate by layers with the diorite, which we have seen above mixed with carburated slate, and amphibolic serpentine. These close relations of rocks so different in appearance, and so fitted to embarrass the geognost, give a great interest to the vicinity of Ortiz. If the *masses* of diorite and amygdaloide which appear to us to be layers, are very large veins, they may be supposed to be formed and heaved up simultaneously. We are now acquainted with two formations of amygdaloide; one, the most common, is subordinate to basaltic soil; the other, much more rare *, belongs to pyroxenic porphyry †. The amygdaloide of Ortiz draws near, by its oryctognostic characters, to the former of those formations, and we are almost surprised to find it fixed, not to basalt, but to phonolite ‡, an eminently feld-

* We find examples of the latter in Norway (Vardekullen, near Skeen), in the mountains of Thuringerwald, in South Tyrol, at Ilefeld in Harz, and at Bolanos in Mexico, &c.

† Black porphyries of M. de Buch.

‡ There are pholonithes of basaltic soil (the most antiently known) and phonolithes of trachytic soil (Andes of Mexico). See my Geogn. Essay, p. 347. The former are

spathic rock, in which we find some crystals of amphibol, but pyroxene very rarely, and never any olivine. The Cerro of Flores is a hill covered with tabulary blocks of greenish grey phonolithe, inclosing long crystals (not fendilated), of vitrous feldspar, altogether analogous to the phonolithe of Mittelgebirge. It is surrounded by pyroxenic amygdaloide; it would no doubt be seen in the depth, issuing immediately from gneiss-granite, like the phonolithe of *Biliner Stein* in Bohemia, which contains fragments of gneiss stuck into the mass.

Does there exist in South America another groupe of rocks, designated preferably by the name of volcanic rocks, and which are as distinct from the chain of the Andes, and advance as far towards the east, as the groupe that bounds the steppes of Calabozo? Of this I doubt, at least in that part of the continent situated to the northward of the Amazon. I have often directed the attention of geognosts to the absence of pyroxenic porphyry, trachyte, basalt, and lavas (I range these formations according to their *relative age*), in the whole of America eastward of the Cordilleras. The

generally above the basalts; and the extraordinary developement of feldspar in that union, and the want of pyroxene have always appeared to me very remarkable phenomena.

existence even of trachyte has not yet been verified in the *Sierra Nevada de Merida*, which links the Andes with the chain of the shore of Venezuela. It would seem as if the volcanic fire, after the formation of primitive rocks, could not pierce into eastern America (Vol. vi, p. 583). Perhaps the little wealth, and the little frequency of argentiferous veins observed in those countries, arises from the absence of more recent volcanic phenomena*. M. d'Eschwege saw at Brazil, some layers (veins?) of diorite, but neither trachyte, basalt, dolerite, nor amygdaloide; and he was therefore more surprised to see, in the vicinity of Rio Janeiro, an insulated mass of phonolithe, entirely similar to that of Bohemia, pierce the gneiss soil†. I am inclined to believe that America, on the east of the Andes, would have burning volcanos if, near the shore of Venezuela, Guyana, and Brazil, the series of primitive rocks were interrupted trachytes. The trachytes, by their fendillation, and open crevices, seem to establish that permanent communication between the surface of the soil and the interior of the globe, which is the indispensable condition of the existence of a volcano. If we direct our course from the coast of Paria, by the gneiss-granite

* See my geogn. Essay, p. 118, 120.

† Manuscript notes of Baron d'Eschwege.

of the Silla of Caraccas, by the red sandstone of Barquisimeto and Tocuyo, the slaty mountains of the Sierra Nevada de Merida, and the eastern Cordillera of Cundinamarca, to Popayan and Pasto, taking the *rumb* of the west and south-west, we find in the vicinity of those towns the first volcanic mouths of the Andes, still burning, those which are the most northerly of all South America; it may be added, that those craters are found where the Cordilleras begin to furnish trachytes at a distance of 18 or 25 leagues from the actual coast of the Pacific Ocean*. Permanent communications, or at least such as are frequently renewed, between the atmosphere and the interior of the globe, have only been preserved along that immense crevice on which the Cordilleras have been heaped up; but the subterranean volcanic forces do not display less activity in eastern America, in shaking the soil of the Cordillera of the shore of Venezuela, and of the groupe of Parime†. In describing the phenomena which

* I believe the first hypotheses on the relation between the burning of volcanoes, and the proximity of the sea, are found in a very eloquent work, little known, of Cardinal Bembo: *Ætna dialogus* (See *Opera omnia Petr. Bembi*, Vol. iii, p. 60); and in *Vicenti Aliarii Crucii Vesuvius ardens*, 1632, p. 164 and 235).

† *See* the classical work of M. de Hoff, on the spheres of oscillations, and the limits of earthquakes, bearing the title:

accompanied the great earthquake of Caraccas*, the 26th March, 1812, I mentioned the detonations which were heard at different periods, in the mountains, altogether granitic, of the Oroonoko. The elastic forces which agitate the soil, the still-burning volcanos, the hot sulphurous springs, sometimes containing fluoric acid, the presence of asphaltum and naphtha in primitive soils, all lead us towards the interior of our planet, of which the high temperature is

Geschichte der nat. Veranderungen der Erdoberflache, 1824, Vol. ii, p. 516.

* I stated in another place the influence which this great catastrophe exerted on the counter-revolution which the royalist party succeeded in producing at this epocha in Venezuela. Nothing is more curious than the negociation which was opened on the 6th of April, by the republican government, placed at Valencia in the vallies of Aragua, with Archbishop Prat (Don Narciso Coll y Prat), to engage him to publish a pastoral letter fitted to tranquillize the people respecting the wrath of the divinity. The Archbishop was permitted to say that this wrath was merited on account of the disorder of morals; but he was enjoined to declare positively, that politics and systematic opinions on the new social order had nothing in common with it; (*declarar que la justicia divina a los mas ha querido castigar a los vicios morales, sin que el terremoto tenga conexion alguna con los sistemas y reformas politicas de Venezuela*). Archbishop Prat lost his liberty after this singular correspondence. See the official documents, published in *Pedro de Urquinaona, Relacion documentada del origen y progresos del trastorno de las provincias de Venezuela,* 1820, Vol. i, p. 72—83).

felt even in our mines of the least depth, and which since Heraclitus of Ephesus, and Anaxagoras of Clazomane, to the Plutonism of modern times, has been considered as the seat of the great agitations of the globe.

The sketch I have just traced furnishes all the *formations* we know in that part of Europe, which has served as the type of positive geognosy. It is the fruit of a labour of sixteen months, often interrupted by other occupations. The formations of quartziferous porphyry, pyroxenic porphyry and trachyte, of grauwacke, muschelkalk, and quadersandstein, which are frequent towards the west, have not yet been recognized in Venezuela; but it may be also observed that, in the system of secondary rocks of the antient continent, muschelkalk and quadersandstein are not always clearly developed, and are often by the frequency of their marls, confounded with the lower shelves of jurassic limestone. The muschelkalk is almost a lias*, with encrinite, and quadersandstone (for there are doubtless many above the lias or limestones with gryphites) seems to me to *represent* the arenacious layers of the lower shelves of jurassic limestone. I thought it my duty to give an extensive developement to the

* *See* the judicious reflexions of M. Boué, in his Memoir on the Alps, p. 24.

geognostic description of South America, not only on account of the interest of novelty which the study of the *formations* in the equinoxial regions excites, but also on account of the honorable efforts which have recently been made in Europe to verify and extend the working of the mines in the Cordilleras of Columbia, Mexico, Chili, and Buenos Ayres. Great capitals have been formed to attain this useful end. In proportion as public confidence has enlarged and consolidated those enterprizes, from which both continents may derive such solid advantages, it becomes the duty of those who have acquired a local knowledge of these countries, to publish the materials that are fitted to give a just appreciation of the relative riches and position of the ore-mines in different parts of Spanish America. The success of *the association for the working of mines*, and that of the labors undertaken by the order of free governments, is far from depending solely on the improvement of the machines employed for draining off the waters, and extracting the mineral, on the regular and economical distribution of the *subterraneous works*, or the ameliorations of *preparation*, *amalgamation*, and *melting*; the success depends also on a thorough knowledge of the different *superposed soils*. The practice of the art of the miner is closely linked with the progress of geognosy; and it may be proved

that several millions of piastres have been rashly expended in South America, from a complete ignorance of the nature of the *formations*, and the position of the rocks, in directing the *labors of research*. It is not solely the precious metals which should now fix the attention of the new *associations of mines*; the multiplication of steam-engines, renders it indispensable, wherever wood is not abundant, or of easy transport, to seek at the same time to discover *coal* and *lignites*. In this point of view, the precise knowledge of red sandstone, or coal-sandstone, quadersandstein and molassus (tertiary formation of lignites), often covered with basalt and dolerite, is of great practical importance. It would be difficult for a European miner, recently disembarked, to judge of a country with a new aspect, and when the same formations cover an immense space. I flatter myself that the work I now publish, as well as my *Political Essay on New Spain*, and my work on the *Position of rocks in the two hemispheres*, will contribute to diminish those obstacles. They may be said to contain the *first geognostic knowledge* of places of which the subterraneous wealth attracts the attention of commercial nations, and they will serve to class the more precise notions which ulterior researches will add to my labors.

The republic of Colombia in its present li-

mits, furnishes a vast field to the enterprizing spirit of the miner. Gold, platina, silver, mercury, copper, gem-salt, sulphur, and alum, may become objects of important workings. The production of gold alone amounted before the epocha of the civil dissensions *, mean year, to 4700 kilogrammes (20,500 marks of Castille). This is nearly half the quantity furnished by all Spanish America, a quantity which has an influence so much more powerful on the variable proportions between the value of gold and silver, that the extraction of the former metal has diminished at Brazil, during forty years past, with surprising rapidity. The *quint* (a tax which the government raises on gold-washings), and which in the Capitania of Minas Geraes, was, in 1756, 1761, and 1767, from 118, 102, and 85 arobas of gold (at 14½ kilogrammes), is fallen, according to manuscript notes kindly furnished me by the Baron d'Eschwege, director-general of the mines of Brazil, in 1800, 1813, and 1818, to 30, 20, and 9 arobas; an arob of gold having at Rio Janeiro, the value of 15,000 cruzades. According to these estimations, the ancient produce of the gold of Brazil, making deductions for fraudulent exportation, was in the middle of the 18th century, in the years of the greatest wealth of the

* See my Political Essay, Vol. iii, p. 394.

gold-washings, 6600 kilogrammes, and in our days, from 1817 to 1820, 600 kilogrammes less. In the province of Saint Paul, the extraction of gold has entirely ceased; in that of Goyaz, it was 803 kilogrammes in 1793, and in 1819 scarcely 75. In the province of Mato Grosso it is almost nothing; and M. d'Eschwege thinks that the whole produce of the gold of Brazil does not amount at present, to more than 600,000 cruzades (scarcely 440 kilogrammes). I dwell on these precise results, because, in confounding the different epochas of the riches and poverty of the *washings* of Brazil, it is still affirmed in all the works that treat of the commerce of precious metals, that a quantity of gold equivalent to four millions of piastres, that is 5800 kilogrammes of gold *, flows into

* The error is double, (*Eschwege, Journal von Brasilien*, Vol. i, p. 218); it is probable that Brazilian gold, *paying the quint*, has not during forty years past, risen to 5500 kilogrammes. I heretofore shared this error with all the writers on political economy, in admitting, from a memoir of M. Correa de Serra, otherwise highly instructive, that the quint in 1810, was still (instead of 26 arrobas or 379 kil.) 51,200 Portugueze ounces, or 1433 kil.; which supposed a product of 7165 kil. (*See* my *Pol. Essay*, Vol. iii, p. 394. Malte Brun, *Geogr.* Vol. v, p. 675. *Lowe, present State of England*, 1822, p. 267.) The very exact information given from two Portugueze manuscripts on the *gold washings* of Minas Geraes, Minas Novas, and Goyaz, in the Bullion Report for the House of Commons, 1810, acc. p. 29, goes as far

Europe annually, from Portugueze America. If, in commercial value, gold in grains prevails in the republic of Columbia over the value of other metals, the latter are not on that account less worthy to fix the attention of government, and individuals. The argentiferous mines of Saint Anne, to Manta, Santo Christo de las Laxas, Pamplona, Sapo, and la Vega de Sapia, give rise to great hopes. The rapidity of the communications between the coast of Colum-

only as 1794, when the *quinto do ouro* of Brazil was 53 arrobas, which indicates a product of more than 3900 kil. *paying the quint.* In the important work of Mr. Tooke (*on high and low prices*, P. II, p. 2), this product is still estimated, mean year (1810—1821), according to Mr. Jacob, at 1,736,000 piastres; while, according to official documents in my possession, the mean of the quint of those ten years amounts only to 15 arrobas, or a product *quint* of 1095 kilogrammes, or 755,000 piastres. Mr. John Allen had already reminded the *Committee of the Bullion Report*, in his critical notes on the table of M. Brongniart, that the decrease of the product of the gold-washings of Brazil had been extremely rapid since 1794 (*Report*, p. 44); and the notions given by M. Auguste de Saint Hilaire indicate the same desertion of the gold-mines of Brazil. The antient miners become cultivators (*Hist of the most remarkable plants of Brazil and Paraguay*, 1824, Introd., p. 9, and 32). The value of an arrobe of gold is 15,000 cruzades of Brazil, (each cruzade being 50 sols.) According to M. Franzini, the the Portugueze onça is equal to 0,028 kil., and 8 onças make 1 mark; 2 marks make 1 arratel, and 32 arratels make 1 arroba.

bia, and that of Europe, gives the same interest to the copper-mines of Venezuela, and New Grenada. Metals are a merchandize purchased at the price of labour, and an advance of capital; in the countries where they are produced they form a part of commercial wealth, and their extraction vivifies industry in the most barren and mountainous soils. The profits of mines being from their nature often irregular, and as an interruption in the subterranean labors, while it causes an irreparable loss, shackles the plans of a prudent administration, the *system of association* now applied in England to the metallic riches of the New World, will produce the most happy effects, if these *associations* are of long duration, and if the men invested with their confidence, unite, with the practical knowledge of the art of the miner, that of mechanics and modern chemistry; and do not disdain to avail themselves of the light spread in America among men who have followed the labors of working and amalgamation; finally, if they know how to guard against those illusions which the exaggerated hope of gain never fails to excite.

In the map of Columbia which I now publish (March, 1825), the limits are indicated such as they were when the congress, conform-

ably to the 85th and 93d articles of the Constitution, fixed the division into departments and provinces, estimating at the same time the respective population on which the number of representatives depends. These official estimates for the eight departments of the Orooноko (175,000); of Venezuela (430,000); of Zulia (162,000); of Boyaca (444,000); of Cundinamarca (371,000); of Cauca (191,000); of Magdalena (239,300); and of Guayaquil (90,000), nearly such as I stated above (Vol. vi, p. 135), according to the *Gazette of Columbia*, of February 10th, 1822; but they differ a little for the departments of Quito (516,071), and of Ystmo (90,825). The former comprehended in 1822, seven provinces; namely, Quito, Quixos, and Macas (together, 354,748); Jaen (9,000); Maynas (36,000); Cuenca (89,343); Loxa (26,980). The department of the Ystmo is divided into two provinces: namely, Panama (58,625), and Veragua (32,200): total of Columbia, 2,711,296. This official estimate, *founded on no direct numbering*, coincides within nearly 1-57th with that on which I had fixed. According to a recent decree of the congress of Bogota (of the 23d June, 1824), the territory of the republic of Columbia is composed of twelve departments, comprehending altogether thirty-eight provinces, namely: 1. *Orinoco* (principal seat, Cumana), di-

vided into four provinces: Cumana, Barcelona, Marguerita, and Guyana. 2. *Venezuela* (principal city, Caraccas), divided into two provinces: Caraccas, and Carabobo. 3. *Apure* (principal town, Varinas), divided into two provinces: Varinas and Apure. 4. *Zulia* (principal city, Maracaibo), divided into four provinces: Maracaibo, Coro, Merida, and Truxillo. 5. *Boyaca* (principal town, Tunja), divided into four provinces: Tunja, Pamplona, Socorro, Casanare. 6. *Cundinamarca* (principal place, Bogota, the antient residence of the viceroy of the *New Kingdom of Grenada*, and not the village of Bogota, now called Funsa); this department is divided into four provinces: Bogota, Antioquia, Mariquita, and Neiva. 7. *Magdalena* (principal place, Cartagena), divided into three provinces: Cartagena, S. Marta, and Rio Hacha. 8. *Cauca* (principal place, Popayan), divided into four provinces: Popayan, Choco, Pasto, and Buenaventura. 9. *Ystmo* (principal place, Panama), divided into two provinces: Panama and Veragua. 10. *The Equator, departemento del Ecuador* (principal place, Quito), divided into three provinces: Pichincha, Imbubura, and Chimborazo. 11. *Assuay* (principal place, Cuenca), divided into four provinces: Cuenca, Loxa, Jaen, and Maynas. 12. *Guayaquil* (principal place, Guayaquil), divided into two provinces: Guayaquil and Ma-

nabi. Before the revolution of the colonies, the whole coast of the Mosquitos, from Cape Gracias à Dios to the Rio Chagre, comprehending the Island San Andres, had been separated, by the royal cedule of the 30th November, 1803, from the Capitania general of Guatimala, and added to New Grenada. We find, for the mean extent of a department of Columbia, 7700 square marine leagues; for the mean extent of a province, 2400 square leagues; one of the twelve new departments of Columbia consequently exceeds in extent thirty-three times, and one of the thirty-eight provinces twelve times a department of France (Vol. vi, p. 187). The mean population of a department of Columbia, of which the surface is equal to twice that of Portugal, is 232,000 souls, that is, half less than the mean population of a department of France. Venezuela, that is the antient Capitania general of Caraccas, has nearly half the surface of the actual presidency of Bengal, but its *relative population* is thirty-six times less. Nothing is more striking than this difference between the antient civilization of India, and those countries of South America where mankind appears to be a colony recently established. In the tables of population of the fine map of Indostan, published by Mr. Carey, in 1824, under the auspices of Colonel Valentine Blacker, chief of the geographical engineers at

Calcutta, the English possessions, and of the allies of Great Britain, are estimated at 123,000,000; namely: British territory in India, eighty-three millions; allies and tributaries, forty millions. The states which I had considered above (Vol. vi, p. 336) with Mr. Hamilton, as being independent, are become allies of the company.

Statement of the Heights of the most remarkable Places of Venezuela above the Level of the Sea.

NAMES OF PLACES.	Height in toises.	NAMES OF THE OBSERVERS, AND VARIATIONS.
Road from La Guayra to Caraccas :		
Maiqueti, at the entrance of the street that leads to Caraccas	13	The whole leveling of the road is indicated in this table from M.M. Boussingault & Rivero.
Curucuti	320	
El Salto, antient fort	479	Profil (Pl. IV, 465 t.)
La Venta	622	(Humboldt, 606 t.)
La Cumbre, the highest part of the road	764	Ht., 763 t.
Caraccas, in the middle of the street of Carabobo	477	Ht., at the great square, 446 t.
Eastern Peak of the Silla of Caraccas	350	Humboldt, Jan. 3d, 1800; Boussingault and Rivero, (Jan. 12th, 1823), 1351 toises.
Road from Caraccas to Merida :		
Hill of Buenavista	835	Humboldt.
Village of San Pedro	584	Ht. (Boussingault and Rivero, 590 t.)
Maracay in the vallies of Aragua	223	B. and R.
La Victoria	270	Ht. (B. and R. 284 t.)
Nueva Valencia	234	Ht. (B. and R. 247 t.
Villa of Cura	266	Humb.
San Carlos	85	B. and R.
Calabozo (the small table-land, *mesa* in the Llanos	94	Ht.
Barquisimeto	76	B. and R.
Tocuyo	322	B. and R.
Truxillo	420	B. and R.
Merida	826	B. and R.
Paramo of Mucuchies, limited to Sierra Nevada de Merida	2120	B. and R.
Mountains of New Andalusia :		
Cumana	3	Humboldt.
Cerro del Impossible	297	Ht.
Cumanacoa	104	Ht.
Table land of Cocollar	408	Ht.
Summit of Turimiquiri	1050	Ht., a little doubtful, trigon. mea.
Cuchilla of Guanaguana	548	Ht.
Convent of Caripe	412	Ht.
Table-land of Guarda of San Augustin	533	Ht.
Catuaro	190	Ht.
Sierra Parime and the banks of the Oroonoko and the Rio Negro :		
Soil of the forests round Javita and the Esmeralda	180	Ht.
The Peak of Duida	1300	Ht. (trigonometrical measure.)
Fort of San Carlos del Rio Negro	127	Ht., a little doubtful.

The barometrical survey, of which I gave the results in my Collection of Astronomical Observations (Vol. i, p. 295—298), has been recently rectified and extended by two travellers well versed in every branch of the physical sciences, MM. Boussingault and Rivero. Wherever my early results differed from theirs, I have given the preference to the latter. M. Boussingault has transmitted the detail of his measurements to the Institute of France. It must not be forgotten, that in my profil of the road from La Guayra to Caraccas (Pl. iv.) published in 1817, the heights of Torrequemada, Curucuti, and Puente del Salto, are simply founded on approximative estimates, and not on real measures. (*Per. Nar.*, Vol. iii, p. 409.) At Salto, la Venta, and Cumbre, M. Boussingault's results and mine differ but little; in the measurement of la Silla, which is the loftiest mountain of those countries, the agreement (accidentally no doubt), is within one toise; but in the town of Caraccas my heights appears less faulty. I believed the custom-house to be 491 toises; the barracks, 462 t.; the Trinity, 454 t.; the great square, 446. According to MM. Boussingault and Rivero, who are furnished with excellent barometers of Fortin, the middle of the street of Carabobo is 477 toises above the level of the sea. We did not measure at the same parts of the town, and modern travellers give

the banks of Rio Guayre 406 t., while (if there is no incorrectness of cyphers in my journal) I found the height 414 t. near la Noria (*See* above, Vol. iii, p. 449). In this uncertainty respecting the partial results, I have confined myself to the indication in the preceding table, for the town of Caraccas, of the *level of the street of Carabobo.* The agreement of my observations with those of MM. Rivero and Boussingault, in the vallies of Aragua, is very satisfactory, for the latitudes, as well as for the heights.

Observations made to verify the progress of the horary variations of the barometer in the tropics, from the level of the sea, to the ridge of the Cordillera of the Andes.

The results of M. Bonpland's observations and mine on the small *atmospheric tides,* during our stay at Cumana, Caraccas, in the steppes of Calabozo, and amidst the forests of the Oroonoko, were published in 1800 and 1801, by M. de Lalande, to whom I had communicated them successively. I flatter myself that this labor has greatly contributed to fix the attention of naturalists in Europe on a very curious phenomenon, of which the cause is not yet completely ascertained. The regularity of the horary variations of the barometer, in the torrid

zone, had been conjectured from the beginning of the 18th century; and the questions which the Academy of Science addressed to M. de la Perouse * tended to explain the part which the attraction of the moon might have in these periodical changes. MM. de Lamanon and Monges made, in 1785, a series of very valuable observations in the Atlantic Ocean, lat. 1° 5′ N. and 1° 34′ S., during three days and three nights, from hour to hour, at a season when the temperature did not change from night to day $1\frac{1}{2}$° Reaum.: but it remained to verify the uniformity of the progress of the barometer in the interior of the continents, in changeable weather, at various heights above the level of the sea. The solution of those problems was the object of a study which I pursued with the greatest care during four years, north and south of the equator, in the plains and on the table-lands of the Cordilleras, at the height of from 1800 to 2100 toises. As no other naturalist has hitherto had the facility of devoting himself to those researches on a *scale of height* so considerable, I shall insert by degrees, in this work, an extract of my horary observations. In order to give more interest to those I made at Venezuela, I have added the barometrical

* *Voyage de la Perouse autour du monde*, Vol. i, p. 161; Vol. iv, p. 257.

heights of Lima, in the southern hemisphere; of Sierra Leone; and of the southern table-land of India. The following tables furnish the horary variations of the shore of Cumana, La Guayra, Peru, the coast of Africa, and the Isle Taiti; those of Mysore (400 t.); of the valley of Caraccas (480 t.); of Ibague, in New Grenada, at the foot of the Andes of Quindiu (703 t.); of Popayan (911 t.); of Mexico (1168 t.); and of Quito (1492 t.). All these observations are unpublished, with the exception of those of Captain Sabine, which I borrowed from the excellent Meteorology of M. Daniell (*His. Essays*, 1823, p. 254).

HORARY VARIATIONS AT CUMANA, NOR. LAT. 10° 27′ 52″; HEIGHT, 15 TOISES. (*Observations of MM. Humboldt and Bonpland.*)

JULY 1799.			
The 17 at	20½h	Bar. 337·57	Th. 16°
+	21	337·62	
18 at	0	337.54	
	2	337·12	Th. 23°
	3	336·74	
—	3½	336·52	
	6	336.83	Th. 21°
	7½	337.24	
	9	337.75	
+	11	337.90	
	14	337.21	Th. 18½°
	18½	337.62	
+	21	337.71	Th. 20°
19 at	1	337.69	
	2	336.81	Th. 22°
	3½	336.62	
—	4	336.53	
	5½	336.76	Th. 21°
+	11	337.79	
	12	337.51	Th. 18°
	19	337.7	
	20½	338·14	Th. 22°
+	21½	338.42	
	23½	337.93	
20 at	2	337.32	Th. 24°
—	4	336.80	
	10½	337.74	Th. 19°
+	11	337.90	
	13	337.31	Th. 18°
	19½	337.40	
+	21	337.63	
21 at	1	337.23	Th. 23°
	3	337.04	
—	4	336.83	
	9½	337.25	
+	11	337.81	Th. 19°
	12	337.64	
	18½	337.24	Th. 20°
+	21½	337.82	
22 at	0	337.75	
	3	337.21	Th. 23°
—	4	336.95	
	6½	337.32	
	10½	337.64	
+	11	337.71	Th. 18°
	13	337.52	

JULY 1799.			
The 22 at	20h	Bar. 337.43	Th. 18°.
+	21	337.62.	
23 at	1	337.54	
	3	337.21	Th. 23°
—	4	337.03	
	5	337.14	
	7½	337.32	
	10	337.53	
+	11	337.61	Th. 18°.
	11½	337.45	

AUGUST 1799.			
16 at	18h	Bar. 336.62	Th. 18°
+	21	337.20	
	21½	337.10	Th. 22°
	22	337.02	
	23	336.80	
17 at	0	336.73	
	1	336.20	
	2½	336.10	Th. 23°
	3	336.02	
—	4	335.90	
	6	336.12	Th. 19°
	8	336.40	
	9½	336.63	
	10½	336.70	
	11	336.82	
	13	336.51	Th. 18°
	18½	336.25	
	20½	336.81	Th. 19°
+	21	336.85	
	23½	336.70	
18 at	0½	336.51	
	2	336.27	
—	4	335.92	Th. 21°
	8	336.34	

From the 18th to the 24th of July, regularly at two o'clock, a storm, blowing from south-east to south, along the mountains. On the 18th of August, eleven shocks of an earthquake were felt at Carupano. The hygrometer of Deluc, in the morning, 60° to 58°; in the afternoon, 48° to 50°.

HOURLY VARIATIONS AT CUBIANA, HEIGHT, 15 TOISES. (*Continuation.*)

AUGUST 1799.			AUGUST 1799.		
The 18 at	+ 11h	Bar. 336.75	The 23 at	20h	Bar. 336.70
	12	336.71 Th. 18°		+ 21½	336.80 Th. 21°
	18	336.75		22½	337.00
	20	336.94		23½	336.90
	+ 21	337.12 Th. 21°	24 at	1	336.70
	22	337.07		2	336.30
	23	337.07		— 2½	336.52 Th. 23°
19 at	0	337.00		5	336.40
	2	336.65 Th. 23°		7½	336.70
	3	336.45		9	336.95 Th. 23°
	3½	336.30		+ 11	337.05
	— 4	336.24		23	337.00
	5	336.32	25 at	2	336.90
	6½	336.37		— 4	336.80 Th. 28°
	10	336.80		5	336.80
	+ 11	336.95 Th. 19°		7	336.80
	12	336.84		+ 10	337.00
21 at	18½	336.68 Th. 18°		12	336.90 Th. 18°
	+ 21	337.12		13	336.84
	22	337.05		20	337.41
22 at	1	336.80		+ 21	337.50
	2	336.60 Th. 23°		22	337.40
	3	336.40		23	337.23
	— 4	336.40	26 at	0	337.05 Th. 23°
	7½	336.52		0½	336.70
	10½	336.68		1	336.75
	+ 11	336.75		3	336.45
	12	336.65		— 4	336.40
	15	336.50		5	336.40 Th. 22°
	— 16½	336.40 Th. 17°		7	336.50
	17	336.53		10½	337.10
	+ 21	337.10		+ 11	337.25 Th. 18°
	22	337.05		13	337.08
	23	336.90		20½	337.10
23 at	0	336.85 Th. 22°		+ 21	337.18 Th. 19°
	1	336.70		23½	337.18
	3½	336.00	27 at	0½	337.05
	— 4	336.00		1	336.82
	5	336.13		2	336.80 Th. 23°
	7½	336.50			
	9	336.65			
	10½	336.80			
	+ 11	336.85 Th. 19°			
	12	336.50			
	— 15	336.50			
	16½	336.55			
	19	336.53			

The 24th and 30th August, furious electric storms appear to have interrupted during some instants, the movement of the barometer. The instrument retrograded on the 24th and the 30th, at the same hour at half past 2 in the afternoon.

HORARY VARIATIONS AT CUMANA, HEIGHT 15 TOISES. (*Continuation.*)

AUGUST 1799.			AUGUST 1799.		
The 27 at	4h	Bar. 336.51	The 28 at	23½h	Bar. 336.76
	5½	336.53	29 at	0	336.50 Th. 24,5°
	6½	336.59		2	336.25
	8½	336.75	—	4	335.75
+	11	336.83		4½	335.78
	12	336.80 Th. 17,5°		6½	336.05 Th. 19,7°
	16	336.75		10½	336.52
	16½	336.70	+	11	336 57
	17	336.90		12	336.40 Th. 18,2°
	19½	337.18		16	335.72
	21	337.20	—	19½	336.17 Th. 21°
+	23	336.95		20	336.25
28 at	0½	336.70 Th. 25,5°	+	21	336.75
	1	336.62		21½	336.70
	2½	336.29		22	336.60
	3½	336.18 Th. 25,7°	30 at	2	336.60 Th. 24°
—	4	336.15		2½	336.75
	4½	336.25	—	4	335.72
	7	336.60 Th. 18°		5½	335.74
+	11	336.50		8½	336.25
	12 11	336.40	+	11	336.50 Th. 19°
+	21	337.27			

HORARY VARIATIONS AT CUMANA, HEIGHT, 10 TOISES. (*Continuation.*)

NOVEMBER 1799.			NOVEMBER 1799.		
The 3d at	20½h	Bar. 336.80	The 5 at	11h	Bar. 336.86
+	21	336.83		13	336.32
4 at	1	336.04	—	16½	336.28
—	4½	335.92		20	337.30
	10	336.20	+	21	337.64
+	11	336.42		21½	337.76
	12	336.26	6 at	0	336.47
	15	336.02		5	336.24
—	16	335.90	—	4	336.28
	20	336.94		5	336.32
+	21	337.02		8½	336.63
	22	337.00	+	11	336.90
5 at	1	336.72		13	336.52
	3	336.25	—	16	335.95
—	4	336.20		18	336.70
	9½	336.52	+	21	337.34

On the 4th of November, at 4h 12' in the afternoon, a violent shock of an earthquake took place. (*See* above, Vol. iii, p. 315, 316.) Thermometer in all the observations at Cumana, at the division of Reaumur.

Horary Variations at La Guayra, Nor. Lat. 10° 36′ 19″; Height, 5 toises. (*Observations of MM. Boussingault and Rivero.*)

	NOVEMBER.					NOVEMBER.				
	Days.	Hours.	Millimet.	Therm. cent.	Hygr.	Days.	Hours.	Millimet.	Therm. cent.	Hygr.
	23	8	763.65	25.0	88		7	762.20	27.0	92
		9	763.80	25.3	86		8	763.0	27.0	91
+		10	764.0	25.8	87	+	9	763.55	26.5	90
		11	764.0	27.0	90		10	763 35	26.3	87
		noon	763.35	28.1	90		11	763.15	26.0	86
		1	762.75	28.5	89		midnt.	763.05	25.3	85
		2	762.35	28.8	88					
		3	761.95	28.8	90	From 8 o'clock in the morning till midnight. These observations were made with an excellent barometer of Fortin. Thermometer centesimal. Hygr. of Saussure.				
—		4	761.70	28.0	91					
		5	761.75	27.3	91					
		6	762.75	27.4	93					

Horary Variations at La Guayra, Height 5 toises. (*Continuation.*)

	NOVEMBER 1822.						NOVEMBER 1822.					
	Days.	Hours.	Millimet.	Therm. cent.	Hygr.	State of the sky.	Days.	Hours.	Millimet.	Therm. cent.	Hygr.	State of the sky.
	24	3	762.06	24.8	83	fine weather.	25	5	761.70	26.5	98	
—		6	762.80	24.5	84	(morning.)	+	11	762.65	25.3	94	
		7	763.0	24.6	84		26	7	762.35	24.5	94	fine weather.
		8	763.70	25.3	84			9	763.30	26.0	92	(morning).
		9	764.20	26.7	83		+	10	763.45	27.4	94	
+		10	764.35	26.8	81			11	763.10	28.4	93	
		11	764.0	28.2				noon	762.45	28.3	93	
		2	762.35	28.4		(evening.)		1	761.65	28.3	92	(evening).
—		4	762.0	27.6	100	rain.		2	761.65	28.1	93	obs. weather.
	25	7	763.70	25.0	96	fine weather.		3	760.65	28.0	93	obs. weather.
		8	763.95	26.2	95	(morning).	—	4	760.60	27.7	93	clouded.
		9	764.25	26.3	96			6	760 60	27.5	94	very clouded.
+		10	764.30	27.7	96			7	761.0	26.9	94	(evening).
		11	763.25	27.6	100	fine weather.		8	761.20	26.8	93	cloudy.
		noon	762.95	26.9	100		+	11	762.05	26.3	91	cloudy.
		2	761.70	27.0	100	(evening).		midt.	761.15	26.6	91	
		3	761.50	27.0			27	7	762.35	26.5	90	(morning).
—		4	761.50	27.0				8	763.0	26.6	91	

HORARY VARIATIONS AT LA GUAYRA, HEIGHT 5 TOISES. (*Continuation.*)

NOVEMBER 1822.

Days.	Hours.	Millimet.	Therm. cent.	Hygr.	State of the sky.
27	9	763.25	27.3	89	fine.
+	10	763.45	28.6	89	
	11	763.15	18.7	89	
	2	760.25	29.2	86	(evening).
—	4	761.0	28.1	92	storm.
	8	761.15	27.0	90	cloudy.
+	11	762.60	26.2	89	
28	2	761.45	26.5	88	(morning).
—	3	761.10	26.5	90	
	6	762,0	27.0	99	
+	9	764.70	28.3	89	
	10	763.50	29.0	88	
	11	763.10	29.0	91	obscure.
	1	761.15	28.0	100	(evening).
	2	762.0	27.7	100	storm.
—	4	761.65	26.7	98	
	10	763.05	25.5	87	
+	11	763.20	26.0	95	
29	4	762.0	25.0	94	(morning).
—	7	763.75	26.0	100	gale at sea.
	8	764.0	26.5	100	
+	9	764.25	26.8	100	fine weather.
—	4	761.65	27.4	100	(evening).
	10	764.80	27.1	100	
+	10½	763.65	27.8	100	
	midt.	763.70	26.9	92	
30	8	764.0	26.0	90	(morning).
—	10	764.20	27.5	90	
+	11	763.95	28.7	93	fine.
+	4	761.80	27.9	92	(evening).
	11	763.30	26.0	95	

DECEMBER 1822.

Days.	Hours.	Millimet.	Therm. cent.	Hygr.	State of the sky.
1	6	762.20	24.5	89	
	9	763.50	27.0	86	
+	10	763.90	27.9	90	starry.
	11	762.15	28.2	95	
—	4	761.35	27.8	86	
+	11	763.0	26.0	87	
6	10	762.65	27.0		(morning).
+	11	762.0	27.8		blue.
	noon	761.70	28.0		
	1	761.35	28.5		(evening).
	2	760.80	28.5		
	4	760.70	27.7		
—	4½	760.65	27.5		blue.
	5½	761.0	26.5		
	10	762.50	26.9		
7	8	763.35	25.5		(morning).
	9½	763.95	27.0		
+	10	764.20	27.3		fine.
	11	763.65	27.7		
	noon	763.60	27.2		
—	4	761.50	26.2		(evening).

I have cited above, (Vol. iii, p. 386) some hor. observations made at La Guayra. On the 5th March, 1822, Colonel Lanzy found, at the house of the Commandant, with a barometer of Fortin 764,40, at ten in the morning, and at 4 in the evening, 761,50: the th. marked 24° and 27° cent. M. Lanz (26 Feb.) observed on the sea-shore at noon, 767,05, the therm. being 26°.

Horary Variations at Lima, South Lat. 12° 2′ 34″; Height 85 Toises. (*Observ. of M. de Humboldt*).

November, 1802.			
Days.	Hours.	Baromet.	Th. Fa.
19	15	329.90	63.3
—	16	330.40	
	21	330.69	
+	22½	330.54	65.2
20	0	330.13	
	1	330.00	
	2	329.92	68.5
	3	329.80	
	3½	329.78	
—	4	329.73	
	5	330.00	
	7	330.13	66
	8	330.54	65
	9¼	330.54	
	10	330.76	64.5
+	11	330.69	
	11½	330.27	65.5
20	18	330.26	
+	20½	330.54	70.3
	23½	329.89	80.5
21	1	329.59	79
	2½	329.32	75
	3	329.05	74
—	4	328.92	72
	7½	328.86	64.5
	8	330.00	65
	9	330.06	
	9½	330.18	
	10	330.13	65.6
+	11	330.13	
	12	330.13	65
	20¼	330.59	70
	22½	330.40	74
	0	330.13	80
+	0¼	329.86	79
22	1	329.46	79

The 20th, by obscure and foggy weather; the 21st by a clear sky.

November, 1802.			
Days.	Hours.	Baromet.	Th. Fa.
22	1½	329.32	72½
—	5½	329.49	68
	6½	329.73	66
	7½	329.78	65
	8	329.86	67.8
	9	330.27	65.5
+	11	330.25	65.5
	12½	330.13	65
+	21	330.87	68.5
	21½	330.53	71
	22¼	330.27	76.5
	0	330.00	
23	1	329.86	80.5
	2½	329.59	79½
	3½	329.46	76
—	4½	329.59	73
	5½	329.73	71.2
	7½	330.54	68
	8	330.67	65
	9½	330.81	64.5
+	11	330.94	65
	1	330.54	65

The weather was foggy at Callao de Lima till five in the morning, on the 9th November. The barometrical observations were made with an excellent English barometer of Gabory, belonging to M. de Quevedo, captain of a ship, commanding the Spanish frigate *la Rufina*. (The hundredths of English inches were reduced into fractions of lines of the ancient French foot). I have here previously noted some Peruvian observations, in order to present in the same point of view, the horary variations between the tropics, and on the north and south of the equator.

Horary Variations at the Port of Callao, South Lat. 12° 3′ 19″; Height 6 toises. (*Observ. of M. de Humboldt.*)

November, 1802.				November, 1802.			
Days.	Hours.	Baromet.	Th. cent.	Days.	Hours.	Baromet.	Th. cent.
8 Nov.	20	337.05		+	21	337.35	18.3
+	21	337.28			22½	337.13	20.4
	22	337.23	19.2	9 Nov.	0½	336.90	20.1
	2½	336.85			0½	336.75	
	3	336.68	20.4		8½	336.63	22.8
	3½	336.65			4	336.45	
	4	336.50			5	336.50	18.4
—	5½	336.75			8	336.85	
	7	337.10	17.3		9	336.95	16.5
	7½	337.20			10	386.97	
	8½	337.25		+	11	336.15	
	9	337.25			11½	336.90	16.7
	10	337.30	16.3		13	336.84	—
	11	336.98			20	337.55	
+	13	336.72			20½	337.65	17.3
	14	336.60		+	21	337.57	
	15	336.65			22	337.45	
	15½	336.62	16.0	10	23½	337.30	19.2
	16	336.55			0	337.25	
—	16½	336.80			0½	337.05	
	17	336.87	16.4		1	336.90	
	17½	336.95			1½	336.93	21.5
	20	337.25	18.0		1½	336.60	

Horary Variations observed on the Coast of Africa, and at Taiti.

At Sierra Leone (Lat. 8° 30′ Nor.) by Captain Sabine.

		Bar.	Therm.			Bar.	Therm.
Mar. 20, at	21h.	29.875	81.2° F.	Mar. 21 at	+ 10h	29.870	
	+ 21½	29.676			19	29.818	80.7°
	22	29.872			22	29.828	
Mar. 21	0	29.876			+ 22½	29.830	
	0½	29.872			23	29.828	
	2	29.828	84°	Mar. 22	3	29.774	
	3½	29.810			— 4	29.760	
	— 4	29.808	81°		5	29.772	
	8½	29.812			9	29.808	
	9	29.850	80°		+ 10	29.814	82.5°

Horary Variations observed at Taiti.

At Taiti (Lat. 17° 29′ South), by M. Iwan Simonoff.

		Bar.	Therm.			Bar.	Therm.
Aug. 5, at	14h.	30.06	80½° F.	Aug. 6 at	— 16h	30.11	79°
	— 15	30.05			20	30.18	77°
	17	30.08	79°		+ 21	30.19	
	+ 20	30.14			0	30.17	79°
	21	30.13	78½°		— 3	30.11	
Aug. 6,	0	30.07			7	30.16	79°
	— 4	30.05	80°		+ 10	30.18	
	9	30.14	78°		14	30.14	
	+ 10	30.15			— 15	30.13	79°
	15	30.12					

HORARY VARIATIONS AT CHITTLEDROOG, ON THE TABLE-LAND OF MYSORE (NORTH LAT. 14° 11′), AT THE ELEVATION OF 400 TOISES, OBSERVED BY CAPTAIN KATER.

Days.	Hours.	Baromet.	Therm.	Days.	Hours.	Baromet.	Therm.
Aug. 5	0	27.51	75 F.	Aug. 6	13	27.45	70 F.
	2	27.48	74		15	27.43	70
	3	27.48	73	—	17	27.42	71
—	5	27.46	72		18	27.43	71
	6	27.47	72		20	27.46	71
+	8	27.51	72	+	23	27.50	73
	9	27.51	73	Aug. 7	1	27.50	74
	12	27.51	71		3	27.45	76
—	15	27.44	71	—	4	27.44	75
	17	27.44	71		5	27.47	75
	19	27.44	72		8	27.50	73
	20	27.48	72	+	11	27.51	72
+	22	27.48	74		13	27.51	72
	23	27.49	75				
Aug. 6	1	27.47	76				
	2	27.45	76				
—	3	27.42	76				
	4	27.42	76				
	5	27.42	75				
	6	27.45	73				
+	10	27.50	72				
	12	27.50	70				

The barometric heights, in hundredths and thousandths of the English inch, in the observations of Africa, Taiti, and Asia. The latter were made during rainy weather, and at the season of monsoons.

Horary Variations at Caraccas, North Lat. 10° 30′ 50″; Height 480 toises. (*Observ. of M. de Humboldt.*)

November and December, 1799.

Days.	Hours.	Baromet.	Therm. of R.	Days.	Hours.	Baromet.	Therm. of R.
Nov. 30	19½	303.70	13°	Dec. 3	20½	304.22	
+	21	304.21	15°	+	21	304.40	15.0°
	22	304.05			22	304.25	
	23	304.00			22½	304.20	
Dec. 1	0	303.82			23	304.15	
	0½	303.60		5	0	303.80	
	1	303.52	18.7°		1	303.72	
—	4	303.00		—	4	303.00	18.0°
	5	303.25			5	303.20	
+	11	303.84		+	11	303.75	13.0°
	12	303.60			19½	304.00	
	20	303.92			20	304.10	
	21	304.03	16.4°		20½	304.20	
	23	303.80		+	21	304.32	
Dec. 2	0	303.77	18.2°		21½	304.32	
—	4	303.00			23	304.02	17.0°
	5½	303.02		6	0	303.85	
	11	303.70			5	303.46	
	13	303.92		—	4	303.30	
	20	303.60	14.9°		3	303.22	
	20½	303.82			6½	303.40	15.0°
+	21	304.00		+	11	303.72	
	21½	303.92			12	303.60	
	23	303.80		+	21	304.20	
Dec. 3	0	303.72	17.5°		23	303.92	
	0½	303.55		7	0½	303.70	
	1½	303.40	18.2°		3½	303.10	18.2°
—	4	303.10			4	303.00	
	7	303.62			7	303.32	16.0°
	10	303.85			10½	304.01	
+	11	303.90		+	11	304.05	13.7°
	12	303.82			11½	303.95	
	14	303.63			18	303.80	
3	20½	304.25	14.9°		20	304.25	
+	21	304.40		+	21	304.40	
	22	304.32		8	0	304.15	
	22½	304.30		—	4	303.00	
4	3	303.20			5	303.25	16.2°
—	4	303.12	18.2°		7½	303.40	
	7	303.64			11	304.00	14.0°
+	11	303.92			16	303.68	
	12	380.80			17	303.76	

Horary Variations at Caraccas, Height 480 toises.

(*Continuation.*)

December, 1799.

Days.	Hours.	Baromet.	Therm. of R.	Days.	Hours.	Baromet.	Therm. of R.
Dec. 20	20	303.62		—	4	302.54	
+	21	303.80		+	11	303.10	
	23	303.65		+	21	303.55	
21	0	303.60	45.5°	24	0	303.20	17.8°
—	4	302.75		—	4	302.75	
	10	303.30		+	11	303.80	13.4°
+	11	303 45	14.3°				
+	21	303.70					
22	0	303.52					
—	4	302.54					
+	11	303.10					
+	21	304.00					
23	0	302.95					

From the 30th of November, till the 8th of December, a serene sky; but from the 20th to the 24th of December, impetuous rains and winds.

Horary Variations at Ibague, North Lat. 4° 27′ 45″; Height 703 toises. (*Observ. of M. de Humboldt*).

September, 1801.			September, 1801.		
23 at 0h	Bar. 292.6	Th. 18° R.	24 at 20h	293.0	Th. 19.3°
1½	292.5		+ 21	293.7	Th. 20.2°
— 4	292.3	Th. 19°	25 at 0	293.6	
7½	292.7		— 4	292.8	Th. 20.0°
9½	293.0		7	293.1	Th. 18.2°
+ 11	293.1		9	293.4	
12	293.1	Th. 17.6°	+ 11	293.5	Th. 17.7°
+ 21½	293.4		18½	294.0	
24 at 0½	293.3		+ 21½	294.6	
2½	292.7	Th. 19°	26 at 2½	293.7	Th. 21.3°
— 4	292.5		— 4½	293.5	Th. 18.2°
7	292.8		10	294.3	
9½	293.2	Th. 16°	+ 11	294.5	
+ 11	293.3		12	294.2	
12	293.2		+ 20½	294.7	Th. 21°
			27 at 1	294.1	
			— 4	294.0	

The small town of Ibague is situated in a high valley at the foot of the Andes of Quindiu.

HORARY VARIATIONS AT POPAYAN, NOR. LAT. 2°-26′ 17″-3 HEIGHT 911 TOISES. (*Observations made in May, 1801, by Don Josef Caldas.*)

MAY, 1801.			MAY, 1801.		
16 at 3h	274.8	Th. 16°	19	275.3	
— 4	274.7		21	275.4	
7	274.9		19 at 2	275.3	
9	275.5		3	275.2	
+ 11	275.6		+ 10	275.4	
19	275.1		20 at 20	275.3	Th. 14°
21	275.3	Th. 15°	+ 22	275.4	
22	275.1		21 at 0	275.1	
17 at 3	274.4		— 3	274.5	
— 4	274.3		7	275.0	
7	274.4		+ 11	275.3	
8	274.7		18	275.3	
+ 9½	274.9		+ 21	275.3	
10	274.9	Th. 15°	23	275.0	
19	274.9	Th. 14·5°	22 at 2	274.4	
+ 21	275.1		— 3	274.3	
18 at 0	274.9		+ 10	275.1	
— 2	274.3				
3	274.3		The thermometer of the division of Reaumur; the bar. heights, as at Cumana, Lima, Callao, Caraccas, and Ibague, in tenths and hundredths of lines of the French foot.		
6	274.5				
7	274.9				
8	275.0				
+ 9	275.3	Th. 14°			

Horary Variations observed at Mexico, and at Quito, by M. de Humboldt.

At Mexico, Nor. Lat. 19° 25′ 45″; height 1168 toises, in June 1803.

26 at 8h	259.70	Th. 63° F.	27 at 11h	259.78	
+ 11	259.87		+ 12	259.70	Th. 62°
13	259.75	Th. 61°	13	259.45	Th. 61°
— 16	259.40		— 16	259.21	Th. 59°
18¼	259.75	Th. 58.5°	+ 20½	259.65	Th. 63°
+ 21	259.90	Th. 65°	21¼	259.65	
21¼	259.85	Th. 66°	21¾	259.55	Th. 67°
22	259.68		2	258.58	Th. 73.5°
22½	259.60	Th. 68°	— 3¼ 3	258.70	Th. 71°
23	259.55	Th. 68.5°	4	258.70	
27 at 0½	259.70	Th. 71°	4½	258.75	Th. 70°
— 4	258.90	Th. 70°	+ 11	259.26	Th. 67°
7½	259.47	Th. 64°	12	259.00	Th. 64°

At Quito, South Lat. 0° 14′; height 1492 toises, in April 1802.

4 at 20h	244.00	Th. 57° F.	6 at 4¾h	244.61	Th. 56°
21	244.32	Th. 60°	6	244.25	Th. 54°
23	244.25	Th. 63°	7¾	244.15	
5 at 2	244.15	Th. 65°	10	244.10	Th. 47°
3	244.15	Th. 59°	19	243.70	Th. 45°
7	243.60	Th. 55°	20¼	244.45	Th. 63°
8½	243.75	Th. 54°	22	244.65	Th. 66°
10¼	243.80	Th. 52°	22¾	244.70	Th. 67°
12	243.61	Th. 51°.5	7 at 2½	244.70	
20½	244.22	Th. 58°	4	244.65	Th. 66.5°
22	244.70	Th. 67°	7	244.65	Th. 58°
6 at 0½	244.70		11¼	244.15	Th. 52°
3¾	244.70	Th. 61°	12½	243.90	Th. 53°

Horary Variations at the Table-land of Antisana, South Lat. 0° 32′ 52″; height, 2104 toises. (*Observations of M. de Humboldt*).

Mar. 16 at 4h	208.60	Th. 8° R.
8	208.78	Th. 7.2°
13	208.20	Th. 6°
18	208.50	Th. 5.4°

The horary variations of Quito and Antisana were observed in rainy weather. They are at that period less sensible, and less regular than at Mexico, and Santa Fe de Bogota.

In order to avoid in the preceding tables the frequent repetition of the words *morning* and *evening*, the hours are counted (according to the ancient method of astronomers,) from the passage of the sun over the meridian, so that the 21st hour corresponds to nine in the morning. The barometric heights are indicated either in millimetres (in the observations of MM. Boussingault and Rivero), or in lines, and hundredths of lines of the French foot (in my observations at Cumana, la Guayra, Callao, Lima, Caraccas, Ibague, Popayan, Mexico, Quito, and Antisana); or finally, in inches, and hundredths of the English inch, (in the observations of MM. Kater, Sabine, and Simonoff). The thermometer was suspended by the side of the barometer, when it was not placed in the instrument itself. The barometric heights are not yet corrected by the temperature, that is, they have not been reduced to zero, or to the same degree above the freezing point. It thence results that, as the barometer sinks from 21 hours to 4, while the heat augments, the extent of the diurnal variation is partly masked in the tables, by this increase of temperature; the same thing takes place from 4 till 11; the movement of the thermometer being still opposed to that of the barometer. On the contrary, the apparent extent of the variations in the atmospheric tides, from 11^h to 16^h, and

from 16h to 21h, are greater than the real variations, because at those epochas the barometer and thermometer rise and sink together.

The same thing has happened in respect to the horary variations of the barometer, as takes place with respect to a great number of important phenomena, which the history of physical discoveries displays in the first instance, that are either vaguely perceived, or carefully examined, but published by insulated observers, who enjoy little celebrity. These phenomena remain forgotten if the learned, or the academies, which in every age exert a great influence on the progress of the sciences, have not made them an object of their researches. When, afterwards, by the union of several observers known by other labours, or by a more complete discussion of the phenomena, doubts are dissipated, things are then eagerly recognized as anciently known, which it is no longer permitted to neglect as ill-observed. A learned man, father Cotte, who has rendered essential services to meteorology, attributed, in 1774, notwithstanding the uniform testimony of so many travellers who had visited the tropics, the regularity of the horary variations to the imperfection of the barometers, that is, to a small quantity of air contained in the void of Torricelli, and susceptible of being dilated and condensed by the increasing and de-

creasing heat of the day *. The first horary observations having been made only near the coast, Mr. Playfair, whose extensive knowledge and superior abilities have never been contested, believed for a long time † that the atmospheric tides observed in the equinoxial zone, were owing to the alternating winds from land and sea. The periodical regularity of those tides may now be regarded as one of the physical phenomena that are best known and most universally verified. It has been ascertained at the same time in the vast extent of the Ocean, and in the interior of the land; in plains, and at two thousand toises of height; between the tropics, and in the temperate zones of the two hemispheres. Before I mention the results that may be drawn from the numerous observations comprised in the preceding tables, I shall relate succinctly and in chronological order, the various attempts of naturalists to verify the regularity of the horary variations of the barometer.

* *Cotte, Traité de Météorologie;* 1774, p. 314. The author did not recollect that the *minima* of the pressure correspond at the same time with the hottest and coldest hours of night and day.

† *Edinb. Trans.*, Vol. v, pl. iii, p. 6. The same cause was indicated later by captain Flinders, whose long and mysterious detention was deplored by all the friends of justice, humanity, and the sciences. (*Tuckey, Marit. Geogr.*, Vol. i, p. 525.)

MM. Varin, de Hayes, and de Glos * remarked, in 1682, in a voyage undertaken by the King's order, to Cape Verd and the American islands, "that the barometer at Goree is generally lowest when the thermometer is highest, and usually two to four lines higher at night than in the day; and that this instrument changes more from morning till night, than from night till morning."

The observations of father Beze, on the ascension of the barometer in the coolest hours of the day, are also no less vague and inexact †. He has been erroneously cited ‡ by some naturalists, as having discovered at Pondicherry and Batavia, in 1690, the regularity of the horary variations in the tropics. Father Beze observes only, "that he is of the opinion of one of his friends, who thinks that the height of the barometer being so constant in the equinoxial regions, may serve as a common measure, sure, and easily found, for all the different nations of the earth." It appears singular that Richer, charged by the academy in 1671, to examine if the (mean) barometric height was the same at Cayenne and at Paris, had not fixed his attention on the horary variations §.

* *Mém. de l'Acad.*, Vol. vii, p. 452.

† The barometer and thermometer mount at the same time, from sunrise to nine in the morning.

‡ *L. c.* p. 859.

§ *L. c.* p. 323.

The phenomenon of horary variations was observed in 1722, for the first time, and pretty completely in the tides of day and night, by a Dutch naturalist, whose name has not descended to our times. It is said, in the *Literary Journal of the Hague*: "The mercury rises,* in that part of Dutch Guyana, every day regularly from 9^h in the morning to nearly $11\frac{1}{2}^h$; after which it descends till towards 2^h or 3^h in the afternoon, and then returns to its first height. It has nearly the same variations at the same hours of the night; the variation is about $\frac{1}{3}$ of a line or $\frac{1}{4}$ of a line, at the utmost a whole line. It were to be wished that the philosophers of Europe would make their conjectures on this point." The observations I made seventy-seven

* *See* extract of a letter from Surinam, in the *series of the year* 1722, p. 234. The observations, in that letter, prove that the author was occupied in determining the *mean height* of the barometer at the Hague and at Surinam. After observations of six years, he believes the former to be 336·1 lines, and the latter 336·5 lines (without correction of the temperature?). He also states a very remarkable regularity in the hours when the rains begin in Dutch Guyana. "In the humid season," says he, "the rains at first begin between nine and ten in the morning, and continue every day till between three and four in the afternoon; they afterwards begin towards eleven or twelve; then, towards one or two; and, finally, towards three or four in the afternoon, after which they cease entirely. It very seldom rains in the night; the air, at break of day, is serene at all seasons."

years later, near this coast of Surinam, on the banks of the Oroonoko, confirmed, with the exception of the hour of the *maximum* of the morning, the precision of the first view of the periods; they prove also that the Dutch traveller had watched several nights to determine the *minimum* which precedes two or three hours the rising of the sun. With respect to the "conjectures of the philosophers of Europe," of which the correspondent of Surinam desires to be informed, we cannot hitherto offer any that are satisfactory.

Father Boudier *, from 1740 to 1750, had observed the barometer at Chandernagor in India. He remarked, in the manuscript journals preserved among the papers of M. de l'Isle, "that the greatest elevation of the mercury takes place every day towards nine or ten in the morning, and the least elevation towards three or four in the afternoon, and that during the great number of years that the barometer has been fixed at Chandernagor, there are not eight or ten days in which this uniform movement of mercury has not been observed." Yet Chandernagor is situated nearly at the extremity of the equinoxial region, in 22° 51′ north latitude.

The academicians who were sent to Quito in

* See *Cotte, Traité de Météorologie*, p. 243. *Mémoires sur la Météorologie*, Vol. ii, p. 302.

1735, had no knowledge when they left Europe, of the observations made at Surinam, on the regularity of the atmospheric tides; MM. Bouguer and Condamine attributed the discovery of this regularity to one of their colleagues, M. Godin. "I also made some observation, says la Condamine *, on the barometer, in the year 1741, at first with M. Godin, and afterwards alone, in order to confirm M. Godin's remark, who first perceived several daily and periodical variations. I found the barometer at its greatest height towards nine in the morning, and at its least towards three in the afternoon; the mean difference (at Quito) was 1¼ of a line." M. de la Condamine, in his *Relation du Voyage à l'Amazone*, returns to the same subject. "M. Godin," he says, "remarked that the variations of the barometer (in the equinoxial zone,) alternate very regularly; one experiment consequently suffices to judge of the mean barometric height †."

* *Voyage to the Equator*, p. 50 and 109. Bouguer, who speaks with the same brevity of the observation of Godin, adds, that the variations of the barometer at the equator, are two to three lines at the seashore, and about one line at Quito. (*Figure de la Terre*, p. 39). We see by the work of M. Thibault de Chanvalon, that Bouguer's manuscripts contained a great number of unpublished horary observations, *Voyage à la Martinique*, p. 135 (22).

† *Voyage à la Riv. des Amaz.*, p. 23. I have founded on

In 1756, a naturalist, whose sagacity and rare merit were not sufficiently appreciated by his contemporaries, M. Thibault de Chanvalon*, first reduced the horary observations he had made in the West Indies, into tables. "The barometer," he observes, in a work which was not published before 1761, "is entirely useless at Martinique to indicate the variations of the weather; but it affords a singularity which merits to be studied in all its details, and which had been already perceived by an observer at Surinam; but either from the small confidence which travellers generally inspire, doubt was preferred to investigation, or because it requires some celebrity to give credit to extraordinary facts, the truth was never clearly presented to the public. The regularity of the horary variations may be said to have been unknown till the journey of M. Godin to Quito. Soon after my arrival at Martinique, I perceived that the barometer mounted insensibly the whole morning, and after having remained some time without movement, began to lower at sunset. The most considerable revolutions of the atmosphere do not alter this periodical movement of the barometer, which coincides,

an analogous observation, the table I have given for the horary observations applied to the calculations of the height of places, in my collection of *Astron. Obs.*; Vol. I, p. 289.

* *Voyage to Martinique*, p. 135 (20, 21, 25).

sufficiently with the horary variations of the magnetic inclination. Amidst the most violent rains, winds, and storms, the mercury rises or sinks, if it be its time to mount or descend, as if the air were perfectly calm. The same variation takes place at Senegal; for Mr. Adamson, to whom I mentioned it on my arrival in France, had verified the fact by a long series of observations made by a friend in Africa, to whom he had sent a barometer."

Since the year 1761, Doctor Mutis, who cultivated every branch of physical science with success, observed the atmospheric tides at Santa Fe de Bogota, with the greatest assiduity, and during forty years. Above all, he fixed with precision the period of the *minimum* which precedes the sunrise *. Unfortunately, this great mass of observations, which their author concealed with too much care during his life, was only published after his death. M. Mutis, in New Grenada, and Alzate and Gama, in Mexico, are the first naturalists who examined the phenomenon of the horary variations on the back of the Cordilleras, at 1200 to 1400 toises above the level of the sea. Alzate speaks of the hours of the *maximum* and the *minimum*, in the

* *Papel per de Santa Fe de Bogota, para 7 Febr.* 1794, p. 128; and *Semanario de el Nuevo Reyno de Gran.*, Tom. i, p. 55, 128.

introduction of a memoir somewhat rare, and which bears the title of *Observaciones meteorologicas de los ultimos nueve meses de el año*, 1769. The horary observations made at Mexico were at first regarded by Cotte, as owing to the imperfection of the instruments; but, from the year 1784, consequently long before he could have any knowledge of the labors of Lamanon, he recognized * his first error, in attributing the phenomenon "which he thinks he observed in Europe, to a cause which has some relation to the atmospheric tides occasioned by the moon."

Neither the observations of Thibault de Chanvalon (1751), nor the small number published by Alzate (1769) corresponded to the *tropical hours*, that is, to the epochas when the barometer arrives at the convex, or concave summits of the curve of its diurnal variations; in the voyage of Le Perouse, MM. Lamanon and Monzes made the first continued observations in 1785, from hour to hour, during three days and three nights. They were then in the middle of the Atlantic Ocean, between the parallels of 1° nor. lat. and 1° south lat. †

The labors of Lamanon are eight years anterior to those which were undertaken at Calcutta

* *Memoirs of Meteorology*, Tom. ii, p. 304.

† *Voyage de la Perouse*, 1797, Tom. iv, p. 257, 264.

by MM. Trail, Farquhar, Pearce, and Balfour; but as the results of the latter were inserted in the fourth volume of the *Asiatic Researches*, published at Calcutta in 1795, while the voyage of the unfortunate Perouse appeared only in 1797, the observations of India acquired more celebrity in Europe; and from them, at my departure for America, I learnt the regularity of the horary movements of the barometer. Ideas too systematic on the *periodicity* of all the maladies in the torrid zone, and on the influence of the moon on the vital movements, had fixed the attention of some English physicians in the West Indies and at Calcutta, on the variations of the weight of the atmosphere. Doctor Moseley * speaks of horary changes, in his *Treatise on Tropical Diseases* (1792, p. 3, 550, and 556), and Doctor Balfour, who had not less faith in lunar and solar in-

* "The barometer," says Moseley, "presents a phenomenon, in the English West India Islands, and other regions of the tropics, which is not yet verified in the temperate zone; the mercury has two movements by day; one of descent, the other of ascension; they correspond to the diurnal progress of the sun. The mercury mounts as the sun approaches the zenith and the nadir, and descends as the sun recedes from those points." This coincidence is not rigorously true. The author might have observed that the *maxima* precede the passage of the sun by the zenith and the nadir, from one to three hours, and that the *minima* succeed that passage an equal number of hours.

fluence on fevers than the physicians of Jamaica, had the patience to observe the barometer at Calcutta in 1794, during a whole lunar revolution, every half hour.

I began, with M. Bonpland, the series of my observations on the variations of the weight of the atmosphere, July 18th, 1799, two days after our arrival at Cumana, and continued them carefully during five years, from the 12° of south latitude to the 23° of north latitude, in plains, and on table-lands of the same height as the peak of Teneriffe. Since the period of my voyage to the equator, this phenomenon has occupied the attention of almost all the travellers and naturalists furnished with instruments fitted to make accurate observations. I shall confine myself to the mention of the observations of M. Horsburgh *, during his stay on the coasts of China and India; of Captain Kater, in the high plains of Mysore; of M. Ramond, in Auvergne; of MM. Langsdorf and Horner †, who in Krusenstern's Voyage, united more than 1400 barometric heights; of M. d'Eschwege, in the missions of the Coroatos Indians, and on the table-land that surrounds the presidio of S.

* See the letter of this learned navigator, to Henry Cavendish, in the *Phil. Trans.*, 1805, p. 178, and in *Nicholson's Journ.*, 1806, Vol. xiii, No. 50, p. 16 and 56.

† *Mem. de l'Acad. de Petersbourg*, 1809, Tom. I, p. 450, 486.

Joaô Baptista in Brazil*; of M. Arago, in Spain and France†; of M. Freycinet, at Rio Janeiro and in the South Sea; of M. Simonoff‡, astronomer of the voyage of Bilinghausen, who, during the years 1820 and 1821, observed alone, from hour to hour, more than 4300 barometric heights in the southern hemisphere, between 10° and 30° of latitude; of Captain Sabine, on the western coast of Africa; of MM. Boussingault and Rivero, at La Guayra, and in the Cordilleras of Columbia; and of M. Duperey, commanding the French sloop *la Coquille*, who, in his voyage round the world, touched at Payta on the coast of Peru. In the actual state of the physical sciences, it is no longer necessary to verify by new observations the existence of a phenomenon so generally recognized; we rather engage travellers who cannot in their journies in the interior of a continent, follow the movement of the diurnal variations every half-hour, during several moons, to direct their attention successively to the particular circumstances that accompany, or modify the atmos-

* *Journal von Brasilien*, Tom. i, p. 174; Tom. ii, p. 142.

† *See* the result of the meteorological observations given by this learned naturalist at the end of every year, in the *Annales de Chimie et de Physique*, from the year, 1816.

‡ *Iwan Simonoff, Beschreibung der Billinghausischen Entdekkungsreise in das südliche Eismeer*, 1824, p. 33.

pheric tides. Before we ascend to the first causes, we must establish the empirical laws. Those laws comprehend continuity (the want of all irregular interruption), in the movements of ascension, or lowering; the limit-hours or periods of the *maxima* and *minima*; the duration of time, that the barometer is apparently stationary; the mean extent of the horary variations in different latitudes and at different heights; the influence of the seasons, or the phases of the moon, on the tropical hours, and on the extent of the variations. The observer, who, in any spot on the earth, would throw light on any part of so complicated a phenomenon, must (even in the tropics, where the mean drawn from a small number of statements, furnishes results that are sufficiently exact,) relinquish every other kind occupation. To mark the period and extent of the small successive increase or decrease *, requires continual observation (*observatio perpetua*). The horary variations of the barometer may be compared in

* During the summer solstice, the equinox of autumn, and the winter solstice of 1806, as well as during the spring equinox and the summer solstice of 1807, I made *continued observations* at Berlin, conjointly with M. Oltmanns, and furnished with a magnetic glass of Prony, on the horary variations of the magnetic inclination, during twenty-nine days, and twenty-nine nights, every half-hour. The limits of the errors were 6″ to 8″ in arc.

this respect, to those of the magnetic inclination; and the celebrated astronomer * who alone on the continent of Europe marks the latter, measuring daily, during several hours, the amplitude of the elongations of the magnetic needle, will tell us, in publishing his precious observations, what patience and long assiduity such a species of labor requires. I advise the traveller, when he arrives within the tropics, to certify by observations during a day and night without discontinuing, whether the *epochas of the limits* are effectively, in the spot where he would fix his stay, 21^h-22^h; 4^h-5^h; 10^h-11^h; 15^h-16^h. This previous labor will ascertain for him the periods of the day and night when he must be found near his instrument, in order to occupy himself with the different parts of the problem of horary variations; for instance, to examine, in observing every ten minutes, if the *maximum* be attained at 9^h, or at $9\frac{1}{4}^h$ in the morning; if the mercury remain stationary, and how long a time that state lasts; if the tides of the night are stronger than those of the day, &c.

I. Continuity of the Movements. What is at first most striking in the phenomenon of the horary variations between the tropics, is the

* M. Arago.

uninterrupted ascending and descending movement. At the periods when the mercury during twenty-four hours, attains the *maximum*, and the *minimum*, *m*, *n*, *m'* and *n'*, the direction of the movement remains constantly the same, from *m* to *n*, and from *m'* to *n'*, whatever may be the hours in different places of the earth, to which the concave, or convex summits of the curve of diurnal variations correspond. We scarcely find in thousands of American observations, one or two exceptions to the laws I have ascertained. Accustomed to an uninterrupted regularity, the observer is so much struck by the slightest anomaly, that he is often tempted to attribute it to some negligence in the observation, or the want of perpendicularity in the instrument *. At Cumana, for instance, on account of this continuity of the movements, one day and one night suffice to ascertain the type of the progress of the barometer; while in Europe, we must take the mean, not of a decade, but (as we shall soon shew), at least of twenty or thirty days.

II. *Epochas of the maxima, and the minima. Duration of the stationary state.* There is something vague in the manner of indicating

* *See* above, in the observations at Cumana, August 24th and 30th (Vol. vi, p. 666).

the epochas of the limits. We must determine at the same time the moment when the mercury attains its *minimum* and no more changes sensibly, and the moment when the mercury begins again to mount. It happens, as in every thing susceptible of a *maximum* and a *minimum*, that the increase and diminution of the tides of the atmosphere and the ocean, near the extreme limits *, are in proportion to the square of time elapsed since the epochas of the *maxima* and the *minima*. The barometer consequently remains stationary in appearance, before its movement becomes retrograde. This stationary state lasts a longer or shorter time, like the state of the flux of the *sea at low water*. If, at Calcutta, for instance, the heights observed were:

	inches
at 2^h 0′	29,97 (angl. measure.)
2^h 30′	29,97
3^h 0′	29,96
4^h 0′	29,96
6^h 0′	29,96
6^h 30′	29,96
7^h 0′	29,97
7 30′	29,98

It may be said, either that the barometer has attained its *minimum* at 3^h, that it kept at the same height till 6^h 30′ and then began to re-

* *Laplace, Systeme du Monde*, 1813, p. 84.

mount ; or, (which is more theoretically exact, supposing changes that are unperceived by our senses, and alike rapid on both sides of the summit), we may indicate $\frac{3^h + 6\frac{1}{2}^h}{2} = 4^h\ 45'$, as the real epocha of the *minimum*. I have learnt from long experience, that there is often more regularity in the period with respect to the hours of the apparent *maximum* and *minimum*, than in the duration of the stationary state. The apparent *minimum* was attained in South America, for instance, very uniformly during whole months, at from 4^h to $4^h\ 15'$ in the afternoon, but at the same season the barometer rose visibly, sometimes from 5^h, sometimes from $6\frac{1}{2}^h$. I have therefore, in my tables, placed the signs of the *maximum* and the *minimum* (+ and −) near the hours when the mercury appears to have attained the concave and convex summits of the curve. It would have been impossible for me to express by the *half-sum* of *equal heights*, the moment that corresponds thoretically to the real summit, my occupations not having permitted me to do more for discovering the extent of the variations, than observe at the hours when the barometer attains its apparent *maximum*, or *minimum*. According to this remark, the assertion of Dr. Balfour, that the mercury has a prevailing tendency to descend from 10^h in the morning till 6^h in the evening,

is somewhat vague, because the time that the mercury continues to preserve its *maximum* and *minimum* of height, is comprehended in the expressed interval. The tendency of the mercury to descend, or rather the interval between the *maximum* of the morning, and the *minimum* of the afternoon, can only be determined by knowing with precision the half-duration of the stationary states near the limits of 10^h and 4^h.

The observations published at Calcutta being the only ones that have been made during a whole moon, every half-hour, served me to find the difference between the *real* and *apparent maxima*. The following is the *tropical instant*, and the duration of the stationary state, for twenty-seven days.

OBSERVATIONS AT CALCUTTA.

DAYS.	APPARENT MAXIMA.	REAL MAXIMA.	DURATION.
1	8h 30′	8h 45′	0h 30′
2	9 0	10 0	2 0
3	9 0	10 30	3 0
4	9 30	9 45	0 30
5	9 0	10 30	3 0
6	10 0	10 15	0 30
7	10 0	10 15	0 30
8	8 30	9 0	1 0
9	8 0	9 30	3 0
10	9 30	10 15	1 30
12	9 0	9 45	1 30
13	9 30	10 30	2 0
14	9 30	10 30	2 0
15	10 0	10 30	1 0
16	8 0	10 45	5 30
17	9 0	9 30	1 0
18	8 0	8 30	1 0
19	9 0	9 30	1 0
20	10 0	10 15	0 30
21	11 30	11 45	0 30
22	9 0	10 0	2 0
23	10 0	10 45	1 30
24	10 30	10 45	0 30
25	10 0	10 45	1 30
26	9 0	10 0	2 0
27	8 30	9 45	2 30

It results from this table, that, even in the places where, near the extremity of the equinoxial zone, the horary variations become less regular than at Cumana, the epocha of the *maximum* does not vary as much as the duration of the stationary state. We find, for Calcutta:

Mean of the app. max.....	9h	17′
of the real max.....	10	5
of duration.....	1	36

Now, the variations of the *apparent maximum* are separated from the mean, more than eighteen minutes of time, fourteen times on twenty-six; while the same separation of 18′ is found in the duration of the stationary state, nineteen times. The epochas at Calcutta of the *apparent maxima* and *minima* are, employing the observations of a whole month, 9h 15′ in the morning, 2h 36′ afternoon, 9h 32′ of the evening, and 3h 12′ of the morning. The *real maxima*, that is the real epochas of the *maxima*, succeed nearly an hour to the *apparent maxima*.

Are the epochas of the extreme limits, which we have called, with M. Ramond, the *tropical* hours *, the same over all the earth? That

* *Wendestunden*, hours in which the movement *returns* on itself, and which must not be confounded with the hours of the *tropical or equinoxial year*.

question, in the present state of our knowledge, cannot be completely solved. We know generally only the *apparent*, and not the *real* epochas; even the former are not always indicated with sufficient precision. Travellers have observed the *maxima* and the *minima*, as it were by chance, sometimes at the moment when the limits were attained, sometimes an hour later, and while the barometer was in a stationary state. The numerous observations of M. Ramond prove that, in the temperate zone, in 45° and 46° of latitude, the *tropical hours*, or *limit-hours*, change from summer to winter, and that the two points of the diurnal *maximum* and *minimum*, draw nearer noon in proportion as the cold augments *. We are yet ignorant whether similar changes do not precede, in a part of the torrid zone, (at Quito and Bombay, for instance,) the epocha when, under the influence of local circumstances, in the rainy season, it is said, that the regular type of the horary variations has altogether disappeared. We cannot too much recommend this point to the researches of travellers. I shall here note what I have hitherto collected with most certainty on the epocha of the *maxima* and the *minima*.

* *Mem. de l'Inst.*, 1808, p. 103. (*Bibl. Universelle, Février*, 1824, p. 93.)

A. *Within the tropics, or near their limits.* A new revision of all the observations I had made, north and south of the equator, in Spanish America, from 23° north latitude, to 12° south latitude, in the low regions of the steppes, and forests, and on the back of the Cordilleras, where the mean temperature is equal to that of the north of Europe, has not obliged me to modify the results which I published in the *Physical Table of the equatorial regions.* I every where observed that the barometer attains its *maximum* at 9^h or $9\frac{1}{4}^h$ in the morning; that it descends slowly till noon, but rapidly from noon till $4\frac{1}{2}^h$; that it re-ascends till 11^h at night, when it is a little lower than at 9^h in the morning; that it sinks slowly all night till 4^h in the morning, and again rises till 9^h. The duration of the stationary state was so short at Caraccas, Cumana, and Mexico, that, for the *maximum* of the morning, for instance, the mean of my observations yields, *real epocha*, $9^h\,20'$; *apparent epocha*, $9^h\,5'$. I passed a great number of days near the instrument at the tropical hours, in order to ascertain if they were rather 9^h than $9\frac{1}{4}^h$; rather 4^h than $4\frac{1}{2}^h$; and I observed, as I have already said, that in some places of the torrid zone, the moment when the pressure of the air begins to diminish is so marked, that the barometer indicates the real time within a quarter of an hour. When the

duration of the stationary state near the limits is almost null, as at Cumana, the changes are announced when the limit is attained, by a change in the convexity of the column of mercury. The variations appear to be independent of those of the temperature and the seasons. If the mercury was descending from 2^h till 4^h, or rising from 4^h till 11^h, a violent storm, an earthquake, showers, and the most impetuous winds, would not alter its movement; which nothing appears to determine but the real time, or the position of the sun. The regularity of the variations was constant in the rainy season, both in the thick forests of the Atabapo, and on the table-land of Pasto (1600 toises) and of Mexico. When the duration of the stationary state was prolonged, it was most frequently at 4^h in the afternoon, and from 4^h till 9^h in the morning. At Lima, the *maximum* of the evening oscillated from $9\frac{1}{2}^h$ to $11\frac{1}{2}^h$. The observations I made at 4^h in the morning are, unfortunately, the least numerous. The only place where during the course of my voyage I remarked a great deviation, is the town of Quito, situated in a narrow valley, and close to the volcano of Pichincha. I could only make observations in this valley during the months of January, February, and March, where the *maximum*, in very variable and rainy weather, was rather near noon, than at 9^h in the morning, and where

the barometer continued to descend without interruption from noon till midnight. If the variations were alike irregular at the foot of Pichincha, during the whole year, the type of those variations would probably not have been ascertained by M. Godin. I regret not having watched often enough at night at Quito, to judge of the nocturnal tides; but the recent observations which M. Duperrey, commanding the French sloop *la Coquille*, has collected in his voyage round the world, prove, that, south-west of Pichincha, at the point of Payta (lat. 5° 5′ south), the *epochas of the limits* are very regularly, in the month of March, 9^h in the morning and 3^h in the afternoon, 11^h in the evening, and 3^h in the morning. This result is drawn from a fine series of observations made every fifteen minutes during six days and six nights, with a barometer of Fortin. The following table, indicating the hundredths of millimetres, and the degrees of the centesimal thermometer, is extracted from a manuscript journal, kindly communicated to me by M. Arago.

OBSERVATIONS AT PAYTA, IN 1823.

DAYS	HOURS.	BAROMETER.	THERMOMETER.
12th March.	6	762.20	25.0°
	7	762.40	25.3
	8	762.40	25.9
	8½	762.70	26.7
+	8¾	762.80	26.7
	9	762.70	27.2
	10	762.50	26.8
	11	762.10	26.9
	noon.	761.50	28.2
	2	759.80	28.7
	3	759.20	29.1
—	4	759.20	28.8
	5¼	759.20	27.6
	6	759.30	27.7
	9	761.40	26.9
	10	762.30	26.7
	10¾	762.30	26.3
+	11	762.40	26.2
	11¼	762.20	26.1
	midnight.	762.30	26.0
13th March.	1	761.30	25.8
	2	761.10	25.5
—	2½	760.70	25.3
	3	760.80	25.8
	4	761.20	25.3
	5	761.50	25.6
+	9¼	762.30	27.0
	10	762.20	26.8
	noon.	761.20	29.5
—	2¾	759.80	30.9
	4	759.80	30.5
	5	760.00	30.4
	10	761.60	27.3
+	11	769.50	27.4
	midnight.	762.80	26.4

In comparing the hours of the *maxima* and the *minima* in different zones, we must not confound the observations that are made in circumstances altogether different. We must distinguish the places where, during the whole year, in the time of drought, as well as of rains, the barometer furnishes a regular periodic movement, and the places where, during the rainy season and *monsoons*, this movement is interrupted or rendered insensible. According to Thibault de Chanvalon, the influence of these causes is not observed * at Martinique; I remarked it on the continent of Spanish America, only at Quito, in the month of April, and at Vera Cruz, when the north wind blows with the greatest violence. Dr Cassan asserts, that he found great irregularity in the island of Saint Lucia, south of Martinique. "We have observed," he says †, "with great care the famous variation of the barometer, which is independent of the apparent constitution of the atmosphere, and has been celebrated by Godin and Chanvalon. The periodical movement of ascension and lowering takes place, no doubt, twice in twenty-four hours; but the hour of the movement appeared to me much less regulated than is pretended." This assertion of Dr.

* *Voyage à la Martinique*, p. 135 (25).

† *Journal de Phys.*, 1790, Tom. 36, p. 268.

Cassan loses its importance, when we recollect how little precision this naturalist generally observes in his labors. He does not admit that the movements of the mercury, even in their irregularity, correspond perfectly with the movements of the Ocean on the western coast of Saint Lucia; he pretends also, "that the barometric formula used in Europe cannot be applied to the measure of the height of the mountains situated in the tropics." The few observations that have hitherto been published on the horary variations in the island of Saint Domingo * might lead us to suspect inequalities which would only disappear by employing the *mean*; but it is to be feared that travellers, by not observing from hour to hour, have confounded either the different epochas of the stationary state of the barometer, or the effects of the rainy season, and of that of drought. An observer in India, who merits the highest confidence, M. Horsburgh, has made very curious remarks on the climateric and local circumstances, which sometimes mask, or alter the type of the amospheric tides, even in the torrid zone. He saw that the rains at Bombay interrupted the period altogether; but that a tendency

* Chanvalon gives for the limit-hours + 22; — 6; + 10; Moreau de Saint-Mery: + 23; — 3; M. Moreau de Jonnès, + 21; — 2; + 7; — 13. (*Hist. Phys. des Ant. Franç.*, Tom. i, p. 417.)

to regularity is observed, whenever, even for some hours only, the weather begins to grow clear. In the same season, and in the same latitude, the atmospheric tides are very sensible in the open sea, while the *periodicity* disappears on the coast *. M. Horsburgh also observed, that the high lands that bound the strait of Sincapore (a pass of small breadth) suffice to mark the regularity of the horary variations.

It may appear surprising that at the foot of the Cordilleras of Venezuela, New Granada, Quito, and Mexico (at Cumana, La Guayra, Calabozo, Guayaquil, Payta, Lima, and Vera Cruz), the variations attain their extreme limits at the same hours as in the high vallies and table-lands of Caraccas, Santa Fe de Bogota, and Popayan (between 500 and 1400 toises); while in India the configuration of the lands modify in a very striking manner the phenomenon of the atmospheric tides. This difference between America and a small part of equinoxial Asia, appears to arise from climateric circumstances; almost every where between the tropics, the same wind (E.N.E. or E.S.E.) brings layers of air of the same temperature; but in India, the variable *monsoons* occasion extraordinary gusts against the elevated parts of the land. Their effects are not felt far from the

* *Nicholson's Journ.*, Vol. xiii, p. 20.

coast, for M. Horsburgh found at sea, in the latitudes of India and China, an uninterrupted barometric *periodicity*, at all seasons. It is, above all, in studying the position of places, where the deviations of the type are manifested, that the cause which produces the regularity of the atmospheric tides will be made clear.

Since my departure from Lima, the professor Don Hipolito Unanue, and the American Captain Samuel Curson, found, on the coast of Peru and Chili, the same hours of the *maximum* and *minimum* that are indicated in the preceding tables (Vol. vi, p. 670); but M. Unanue informs me, that "these hours appear to change in ascending the Cordilleras of Peru; and that this delay, in the epochas of the extreme limits, appears to him to be owing to the winds which blow differently on the coast of the Pacific Ocean, and in the narrow vallies of the Andes." I do not doubt the possibility of those changes of epochas; but no naturalist has hitherto published a series of observations which indicates them in a regular manner. The question is, whether the winds and rains (as during a part of the year at Bombay and Canton), disarrange the movement of the barometer, so that no type of regularity can be ascertained; or, (which is very different) whether places exist in the equatorial zone, where always, or at one season only, atmospheric tides

are remarked, of which the epochas of *maxima* and *minima* swerve regularly (more than two hours for instance), from the period of 4h till 9h in the morning, and from 4h till 10½h in the evening? The table placed at the end of this memoir will shew that in the only parts of the earth where a sufficient number of observations have been made to furnish with precision the hours when the variations attain the extreme limits, nearly thirty observers have found a striking accordance* in the return of the same epochas.

Places where it has been often too lightly asserted that the periodicity of the atmospheric tides is irregular, have been discovered, after mature examination, to present the greatest regularity in the epochas of the *maxima* and the *minima*. M. d'Eschwege found those epochas precisely similar to those of Cumana, in the low and hot part of Brazil, bounded by the two chains of the Espinhaço and the shore †, for instance at San Joaõ Baptista, in the missions of the Caroatos Indians; while, on the contrary, at Villarica and Rio Janeiro, the type

* An excellent observer, Mr. Colebrooke, affirmed very recently, that even in the interior of India, in most places the periodicity is manifest and independent of the variations of the temperature, and the season of the year. *Asiat. Res.* Vol. xii, p. 266.

† See above, Vol. vi, p. 531.

appeared to be marked by causes of perturbation. We now know that this assertion demands some restriction for Rio Janeiro. M. de Freycinet, who stopped at this port in his last voyage round the world, found in the month of August, consequently in more serene weather, the greatest regularity in the horary variations *.

OBSERVATIONS AT RIO JANEIRO, IN 1820.

HOURS OF THE OBSERVATIONS.	HEIGHTS OF THE BAROMETER in hundredths of millimeter.	HOURS OF THE OBSERVATIONS.	HEIGHTS OF THE BAROMETER in hundredths of millimeter.
11	766.71	23	766.65
midnight	766.77	noon	765.96
13	766.59	1	765.76
14	766.15	2	766.04
15	765.65	3	764.28
16	765.67	4	764.28
17	765.78	5	764.49
18	766.00	6	764.43
19	766.35	7	765.33
20	766.49	8	764.69
21	766.91	9	766.38
22	766.96	10	766.55

* Barometer of Fortin. The heights are reduced to the temperature of zero. If we would have them corrected of the error of the level, it would be necessary to add 0^{mm},922.

These results are even confirmed by older observations than those of Lamanon. M. Sanchez Dorta has published in the greatest detail, in the first volume of the *Memoirs of the Academy of Lisbon*, the barometric heights observed at Rio Janeiro, at three periods of the day, (morning, noon, and evening) during the whole year of 1785. In this table, of more than a thousand observations*, we scarcely find two or three days in a month where any irregularity is remarked; but the hours indicated not being precisely those of the extreme limits, it is better to have recourse to the table in which M. Dorta gives for every month the mean of the hours 18^h, 20^h, 22^h, 24^h, 2^h, 4^h, 6^h, 10^h.

* *Mem. da Academic Real das Sciencias*, 1799, Vol. i, p. 397. The barometer was of the construction of M. de Magalhães.

OBSERVATIONS AT RIO JANEIRO, IN 1785.

MONTHS.	6h in the morning.	8h in the morning.	10h in the morning.	noon.	2h after-noon.	4h after-noon.	6h in the evening.	10h in the evening.	MEAN TIME, FARH. at 10h morning.	MEAN TIME, FARH. at 4h aftern.
January	1.83	2.10	2.22	1.96	1.63	1.26	1.65	2.30	81.1	83.6
February	1.62	1.87	2.12	1.86	1.67	1.30	1.61	2.15	79.4	81.9
March	2.57	2.93	3.18	2.88	2.54	2.28	2.59	3.00	76.1	77.4
July	4.02	4.31	4.65	4.30	3.93	3.69	3.98	4.44	66.7	70.4
August	4.48	4.74	5.06	4.68	4.40	4.18	4.43	4.73	71.2	74.7
September	3.68	3.98	4.22	3.89	3.49	3.33	3.66	4.13	71.7	73.9

The barometric heights * are indicated in this table in hundredths of lines (antient measure of the French foot). In order to disengage them from the influence of the temperature, or reduce them to the freezing point, I have added the mean temperature of the limit-hours in which the mercury attains the *maximum* and the *minimum*. The periodical movement of the horary variations at Rio Janeiro are, as every where else, where the mean of well-made observations can be taken, of the greatest regularity. Nor would it have been extraordinary if among 1095 partial observations, published by M. Dorta for the year 1785, more numerous anomalies had been found; for Rio Janeiro (lat. 22° 54′), is like the Havannah (lat. 23° 9′), Calcutta (lat. 22° 34′), Canton (lat. 23° 8′) and Macao (lat. 22° 12′), near the limit of the torrid zone, where the perturbating influence of the temperate zone begins to be felt.

The doubts thrown on the regularity of the horary variations of the coast of Brazil, are spread still more to the east, as far as Macao, a spot situated at an equal distance from the equator, in the northern hemisphere. A series

* We must add twenty-eight inches to every height, so that the mean height of the barometer at Rio Janeiro, at 10h in the morning, in the month of July was 28in 4li. 65.

of very valuable observations * made during three years by the Abbé Richenet, of the congregation of Saint Lazare, proves, That on the southern coast of China, the atmospheric tides display the most admirably constancy, and that their period is ascertained day by day, without the necessity of having recourse to the mean. I shall choose the driest month (January), in which there was not one day of rain, and the most humid month (June), in which twenty days of rain yielded 732 millimetres of water †.

* These unpublished observations, of which I owe the communication to the kindness of Lord Strathallan, who long resided at Canton and at Manilla, were made with two barometers of English construction, with a thermometer of *maxima* of Six) and with an hygrometer of Saussure. The barometric heights, in hundredths of an English inch, are corrected by the temperature.

† Quantity of water fallen at Macao in 1814, in one hundred and fifty-four days of rain, of which thirty-six were accompanied by thunder: 7ft 7.6in English measure.

OBSERVATIONS AT MACAO, IN 1814.

JANUARY.	BAROMETER.			THERMOMETER.		JUNE.	BAROMETER.			THERMOMETER.	
	10h in the morning.	5h in the evening.	10h in the evening.	maxim. F.	minim. F.		10h in the morning.	5h in the evening.	10h in the evening.	maxim. F.	minim. F.
1	30.35	30.24	30.25	72	66	1	30.07	30.00	30.01	83	79
2	30.26	30.21	30.24	73	67	2	30.08	30.06	30.14	83	80
3	30.34	30.28	30.30	74	67	3	30.18	30.16	30.22	80	78
4	30.39	30.28	30.32	73	69	4	30.25	30.18	30.23	80	71
5	30.34	30.28	30.33	75	70	5	30.12	30.11	30.11	82	77
27	30.32	30.27	30.30	71	65	26	29.89	29.79	29.84	84	82
28	30.35	30.32	30.34	70	67	27	29.83	29.82	29.85	81	78
29	30.41	30.32	30.33	72	67	28	29.87	29.83	29.88	83	78
30	30.29	30.18	30.19	72	68	29	29.84	.....	29.82	82	78
31	30.18	30.13	30.14	74	68	30	29.77	29.73	29.78	84	79

The regularity of the variations marked in the preceding table, are found in more than a thousand heights, which I carefully examined on the registers of the Abbe Richenet. During the course of the whole year 1814, the centigrade thermometer descended at Macao in January, to 5° below the freezing point; it rose at the end of August, to 30·4°. There were frequent tempests, and thirty-six stormy days; more than 2.316 of rain water fell, and amidst so many climateric changes, I did not remark one single period of seventeen hours during which the ascending and descending movements of the barometer (from 5^h in the morning to 10^h, from 10^h to 5^h in the afternoon, and from 5^h till 10^h in the evening) had been interverted.

On the east of Macao, in the South Sea, MM. de Langsdorf, Horner, and Simonoff found, by a mean drawn from 5700 horary observations, the limit-hours nearly the same, namely: M. de Langsdorf, taking the mean for the north and south torrid zone + 9^h 40′ in the morning; — 3^h 55′ afternoon; + $10\frac{1}{2}^h$ in the evening; — $3\frac{1}{2}^h$ after midnight: M. Simonoff, in taking the mean for the space contained between the parallels of 10° and 30° south latitude: + 9^h 24′ in the morning; — 3^h 24′ in the afternoon; + 9^h 30′ in the evening; and — 3^h 18′ after midnight. The Russian astronomer made observations in the equinoxial region of the At-

lantic Ocean, nearly in the same latitudes as Lamanon: but the observations of the latter being much more numerous (extending from 22° 55′ south lat. to 26° north lat., and corresponding with every hour comprised in 32 days and 32 nights), the results to be drawn from them appear to be more worthy of confidence. M. Simonoff stops at + 9h 39′ in the morning; — 3h 23′ afternoon; + 9h 47′ in the evening; — 3h 25′ after midnight. These epochas of the *maxima* and the *minima*, determined by the mean with extreme precision, and by the observer, prove, that notwithstanding a difference of 140° of longitude, the atmospheric tides follow the same hours * within 18 minutes, in the equinoxial regions of the South Sea, and the Pacific Ocean.

B. *In the temperate zone.* When I endeavoured, in the physical table of the equatorial regions †, to call the attention of the learned of Europe to

* This regularity or correspondence of epochas east and west of America, is no doubt very striking; but to disengage the *Atlantic results* of M. Simonoff from the influence of the temperate zone, where he passed from 24° to 26° north latitude; I calculated, on the registers which he confided to me, only the observations made between 8° 26′ south lat. and 8° 22′ north lat. In that extent of the Atlantic, I find + 9h 42′ in the morning, — 3h 30′ afternoon, + 9h 48′ in the evening; — 3h 2′ after midnight.

† See my essay on the geography of plants, 1807, p. 94.

the study of the atmospheric tides, I ventured to predict that "in the temperate climates, where the horary variations of the weight of the air are concealed beneath a multitude of local causes that make the barometer rise and fall irregularly, the *mean*, drawn from a great number of observations made from hour to hour, proves that, in the high latitudes, like those of the torrid zone, the mercury rises and sinks at determinate epochas." That proof, thanks to the zeal of naturalists, has been completely obtained. We shall follow the variations of the tropics towards the temperate zones. M. Simonoff has observed that the hours of the *maxima* and the *minima* are manifested by partial observations, and without having recourse to the mean, in the Pacific Ocean, between the tropic of Capricorn, and the 30° of the south latitude; and in the Atlantic Ocean, between the tropic of Cancer, and the 26° of north latitude. If the greater extension of the *tropical climate* in the southern hemisphere, be confirmed by other travellers, it will be linked with many phenomona which the temperature, the trade-winds, and the vegetation of monocotyledon arborescent plants, present. Mr. Horsburgh found on the east of Africa, in the seas of India and China, that the variations were more regular, and greater, from 10° north lat. to 25° south lat., than from 10° to 20° north of

the equator. M. Leopold de Buch, in his voyage to the Canary Islands, obtained, after twenty days of barometric observations at Las Palmas, in the Gran Canaria, for the extreme limits, 10^h and 11^h in the morning, 4^h in the afternoon, and 11^h in the evening *. M. Coutelle, during the course of the meteorological observations, which he was charged by the Institute of Egypt to make at Cairo, in 1799, 1800, and 1801, did not know the periodicity of the variations of the barometer between the tropics; but a few weeks sufficed to shew him that at all seasons, in 30° 3′ of north lat., the mercury rises from 5^h to $5\frac{1}{2}^h$ in the morning, till 10^h and $10\frac{1}{2}^h$; that it descends regularly till 5^h or $5\frac{1}{2}^h$ in the afternoon; that it remounts till 10^h or $10\frac{1}{2}^h$ in the evening, and again descends till 5^h or $5\frac{1}{2}^h$ in the morning †. In our more northern regions of Europe, Van Swinden ‡, Chiminello §, Duc la Chapelle ** and Hemmer ††, had remarked during forty years, with more or less certainty,

* *Einige Bemerkungen über das klima der Canarischen Inseln*, p. 9.

† *Description de l'Egypt, Mem. d'Hist. nat.* Tom. ii. p. 335.

‡ *Journ. de physique*, 1778, Tom. xii. p. 301.

§ *Saggi scientifi ci di Padova*, 1786, Tom. i. p. 46.

** *Bulletin des Sciences*, an 7, n. 2, p. 162.

†† *Gren, Journ. der Physik.*, B. ii. p. 223. (*Ephemerides Manheim* 1783 and 1789.)

that the barometric variations were subject to certain laws. Van Swinden announced in the year 1776, the existence of a diurnal period: he employed the method of the *mean*, to exclude the effects of accidental perturbations; but he fixed hours for the *maxima* and *minima* ($+1\frac{1}{2}^h$; -6^h; $+10^h$; -22^h astronomic time), which, according to the position of Franecker, and the analogy of the observations of Kœnigsberg, appear little probable. Cotte*, Hemmer, Planer, and other members of the Meteorologic Society of Manheim, ascertained that the passage of the Sun over the meridian, tended to make the barometer descend, and that that instrument was generally lower at 2^h in the afternoon, than in the morning and evening. Duc la Chapelle carefully observed the more or less swelled convexity of the column of mercury, and concluded from his labors, that the barometer lowers in the south of France, from 7^h in the morning till $2\frac{1}{2}^h$ in the afternoon; that it rises till $10\frac{1}{2}^h$ in the evening, and again descends rapidly during the night. All these assertions were vague and contradictory: the first precise observations made in Europe on the horary variations of the barometer, were by M. Ramond. "I obtained," says that excellent observer †, "analagous results to

* *Journ de phys.*, Tom. xxxvii, p. 104.

† *Mem. de l'Institut pour l'année* 1808, p. 100, 103 and 107.

those of M. de Humboldt at the equator, but the hours of variation differ according to the seasons; the *tropical hours* for winter, are at 9^h in the morning, 3^h in the afternoon, and 9^h in the evening. In summer the lowering appears to begin at 8^h in the morning, is continued till 4^h in the afternoon, and begins again at 10^h in the evening. My observations being made alone, it was impossible for me to determine the nocturnal variations with sufficient precision; for in our climates, whole months of assiduous observation do not suffice to limit the quantities which one single night of the equator furnishes in all their purity."

All the remarks of M. Ramond on the epochas of the extreme limits, and the small changes which these epochas undergo in winter and summer, have been perfectly confirmed by the observations made from 1817 to 1821, at Toulouse, by M. Marqué Victor, and from 1822 to 1823, at Chambery, by M. Billiet. The former collected more than 20,000 barometric heights, of which the results are inserted in the *compte rendu* of the labors of the Academy of Toulouse. He observed from six in the morning till midnight, from hour to hour, with extraordinary assiduity and patience. At Toulouse, as at Chambery, and at Clermont in Auvergne, the diurnal *maxima* and *minima* draw nearer to noon more than an hour, in winter, when the

sun rises later; but the type * of summer ($+20^h$; $-4\frac{1}{2}^h$; $+10^h$) is almost identical in Europe with that which I ascertained in the torrid zone ($+20^h$; $-4\frac{1}{2}^h$; $+11^h$). It would be interesting to know if this analogy holds at the epocha of the *minimum* which takes place after midnight ($16\frac{1}{2}^h$), an epocha for which numerous statements are wanting in our climates.

A traveller who has devoted himself with success to the measurement of mountains, M. de Parrot †, asserts, from a series of observations which he made every half-hour, during 14 days and 14 nights, that at Milan, the *epochas of the limits* are: -18^h; $+23^h$; $4\frac{1}{2}^h$; $+12^h$. It cannot be doubted that, in studying the tables of the horary variations of the barometer, published nine years ago by M. Arago, and which I regard, on account of the perfection of the in-

* The type of the winter in Europe, taking the mean between the horary observations of MM. Ramond, Marque Victor, and Billiet, appears to be $+21\frac{1}{4}^h$; $-2\frac{1}{4}^h$; $+9\frac{1}{4}^h$. The differences presented by the *epocha of the limits* in winter and in summer seem to prove, that the most proper hours for observers of the barometer, in our observations in Europe, are (if we would wish them to be uniform for the whole of the year), $9\frac{1}{4}^h$ in the morning; $3\frac{1}{4}^h$ afternoon; and $10\frac{1}{2}^h$ at night. The *minimum* of the morning in Europe seems to fall between 3^h and 4^h after midnight.

† *Reise in den Pyrenæen von Freidrich von Parrot*, 1823, p. 11. This *maximum* of the morning (one hour only before midnight) appears to me very late.

strument, and the choice of the hours (21^h and 4^h), as the most instructive which we hitherto possess; the mean of the two decades suffices to shew that the mercury sinks between 9^h in the morning, and 4^h in the afternoon; but in order to determine the quantity of variations, to know if the *maximum* is attained at 9^h or at 11^h, requires more days of observation in the temperate zone than M. Parrot could devote at Milan.

III. *Extent of the horary variations.* In collecting the whole of my observations at Cumana, I find, for that part of the tropics, and at the level of the sea, the extent of the variations reduced to zero of temperature, from 9^h in the morning till 4^h in the afternoon, to be 1.10^{li} or 2.47^m. I shall add to the results of Cumana those of Caraccas, corresponding to an elevation of 408 toises.

ATMOSPHERIC TIDES OF THE MORNING AT CARACCAS.

DAYS.	MAXIMUM of the morning in lines. 9h.	THERMOMETER OF REAUMUR.	MINIMUM afternoon in lines. 4h.	THERMOMETER OF REAUMUR.	APPARENT DIFFERENCE.	REAL DIFFERENCE reduced to zero.
30th Nov.	304.21	15°	303.00	17°	1.21	1.34
1st Dec.	304.03	16	303.00	18	1.03	1.16
2 ———	304.90	16	303.10	17	1.80	1.87
3 ———	304.40	15	303.12	18	1.28	1.48
4 ———	304.40	15	303.00	18	1.40	1.60
5 ———	304.32	16	303.70	17	0.62	0.69
6 ———	304.20	16	303.00	17	1.20	1.27
7 ———	304.40	16	303.00	16	1.40	1.40
20 ———	303.80	15	302.73	16	1.07	1.14
21 ———	303.70	15	302.54	17	1.16	1.30
22 ———	304.00	16	302.54	18	1.46	1.60
23 ———	303.55	16	302.75	18	0.80	0.94
24 ———	304.20	15	302.94	17	1.26	1.40

ATMOSPHERIC TIDES OF THE MORNING AT CUMANA.

DAYS.	MAXIMUM of the morning in lines.	THERMOMETER OF REAUMUR.	MINIMUM afternoon in lines.	THERMOMETER OF REAUMUR.	APPARENT DIFFERENCE.	REAL DIFFERENCE reduc'd to zero.
17th July.	337.62	17°	336.52	21°	1.10	1.40
18	337.71	20	336.53	22	1.18	1.18
19	338.42	22	336.80	24	1.62	1.77
20	337.74	19	336.83	23	0.91	1.21
21	337.82	20	336.95	23	0.87	1.10
22	337.62	19	337.03	23	0.59	0.89
16th Aug.	336.80	22	335.90	23	0.90	0.98
17	336.85	20	335.92	22	0.93	1.08
18	337.12	18	336.24	23	0.88	1.26
21	337.12	19	336.40	23	0.72	1.02
22	336.90	20	336.00	21	0.90	0.98
23	336.85	21	336.50	23	0.35	0.50
24	337.05	23	336.80	24	0.25	0.33
25	337.50	19	336.40	22	1.10	1.33
26	337.18	19	336.51	23	0.67	0.97
27	336.95	19	336.15	20	0.80	0.88
28	336.76	20	335.75	25	1.01	1.39
29	336.75	21	335.72	24	1.03	1.26

M. Boussingault, in transmitting to me for the Academy of Sciences, the observations of the horary-variations made during a whole year, conjointly with M. Rivero, at Santa Fé de Bogota, speaks as follows of the limit-hours: "It is a fact established by your labors, and verified by ours, that the mercury between the tropics attains its *maximum* between 8^h and 10^h in the morning; then descends till near 4^h, and is at the *minimum*, between 3^h and 5^h in the afternoon; that it then ascends till 11^h at night, without reaching, however, the same height at which it was at 9^h in the morning; and finally, re-descends till 4^h in the morning, without going as low as it was at 4^h in the afternoon. In consulting the whole of our observations made at Santa-Fe de Bogota, in 1823 and 1824, (and there are more than 1200 of them), we remark that the greatest height observed, took place July 16th 1824, at 9^h in the morning: it was reduced to the temperature of zero, of 0.56388^m. The smallest height was observed Nov. 5th, 1823, at 4^h in the evening: it was 0.55768^m. During whole months the barometric heights observed at the same hours, at Bogota, do not differ 0.4^{lm}; and the mercury in the space of a whole year, only oscillated at the epocha of the *maximum* of 9^h in the morning, between 0.55928^m, and 0.56388^m; and at the epocha of the *minimum* of 4^h in the evening

between 0.55768^{m}, and 0.56185^{m}. These are the extreme oscillations." M. Boussingault found the tides at Bogota, from the 4th to the 5th of January, 1824, as follows: (16^{h}) 560.70^{mm}; (17^{h}) 561.00; (21^{h}) 562.75; (22^{h}) 562.75; (23^{h}) 562.65; (noon) 562.30; (1^{h}) 561.60; (2^{h}) 561.25; (3^{h}) 560.80; (4^{h}) 560.50; (5^{h}) 560.65; (6^{h}) 561.10; (7^{h}) 561.55; (9^{h}) 562.60; (10^{h}) 562.75.

M. Arago has submitted to a new examination the observations made by MM. Boussingault and Rivero in November 1822, at the port of La Guayra, almost in the meridian of Caraccas. In reducing these observations to zero of the centigrade thermometer, he finds that from the 23rd November to the 7th December, the mean of 9^{h} in the morning was equal to 760.05^{mm}; that of 10^{h}, to 760.03^{mm}; that of 4^{h} in the evening, to 757.44^{mm}; and that consequently, the mean diurnal variation was 2.44^{mm}. The partial differences of the days varied from 2.04^{mm} to 2.92^{mm}. In comparing all the absolute heights of the barometer observed at La Guayra at the same hour on different days, differences are remarked that rise to 2.10^{mm}. M. Arago * thinks, from the observations of MM. Boussingault and Rivero, that, at the equator as in the temperate climates,

* *Annales de chimie et de physique*, Tom. xxv, p. 428.

the barometric height of noon may be considered, without sensible errors, as the mean of the day. My observations, made at different heights, north and south of the equator, seem to prove that the mean of noon is generally a little more elevated in Equinoctial America, than the mean of 9^h and 4^h, the barometer descending much less rapidly from 9^h till noon, than from noon till 4^h. I draw this result from 260 observations, taken by chance from my registers.

A long series of observations made on a table-land of India, at the foot of the Himalaya, * cannot lead to an analagous result, because the *maximum* of the morning is not indicated; but that series gives with precision the mean of the hours of noon, 3^h in the afternoon, 9^h in the evening, and 4^h in the morning, in hundredths of the English inch.

* Francis Hamilton, formerly Buchanan, Account of the kingdom of Nepaul, 1819, p. 230. In comparing 9^h in the evening and 4^h in the morning, it must not be forgotten that the *maximum* of the evening tide falls between 10^h and

OBSERVATIONS AT KATHMANDU, LAT. 27° 41′.

1802 and 1803.	MEAN HEIGHTS OF noon.	3^h afternoon.	9_h in the evening.	4^h in the morning.	MEAN TEMPERAT. Thermometer of Fahr.
May	25.46	25.40	25.41	25.43	72.8°
June	25.20	25.19	25.18	25.18	74.2
July	25.13	25.11	25.13	25.13	75.5
August	24.98	24.94	24.96	24.96	72.3
September	25.05	25.01	25.03	25.03	71.5
October	25.20	25.16	25.32	25.22	66.1
November	25.31	25.24	25.28	25.34	58.7
December	25.31	25.24	25.31	25.36	51.5
January	25.32	25.27	25.31	25.36	48.1
February	25.28	25.21	25.25	25.26	51.5
March	25.25	25.18	25.19	25.22	56.2
Mean	25.23	25.18	25.22	25.23	63.6

As we are ignorant of the mean temperature of the epochas of the day and night when these observations were made, on the table-land of Kathmandu, the mean of the barometric heights from 3^h in the afternoon till 4^h in the morning, cannot be directly compared together; but the observations of M. Dorta * made at Brazil, (the most numerous and complete which have hitherto been published on the horary variations in the southern hemisphere), furnish the possibility of a direct comparison. I have added the mean temperature of the hours expressed in degrees of the thermometer of Fahrenheit. — In reducing to the temperature of zero the barometric mean of the following table, we find: for 10^h in the morning $28^{in}\ 2.01^{li}$; for noon $28^{in}\ 1.57^{li}$; for 4^h in the afternoon $28^{in}\ 0.97^{li}$; for 10^h evening $28^{in}\ 1.81^{li}$. The extent of the variations is therefore from 10^h in the morning till 4^h in the afternoon, 2.34^{mm}; that from 4^h in the afternoon till 10^h in the evening 1.89^{mm}. The mean of noon is 0.17^{mm}, more elevated than the mean of day,

* *Mem. de Acad. de Lisboa*, Tom. ii, p. 393—398. M. Dorta having made observations only every 2 hours, we could not present the barometric heights of 9^h in the morning and 11^h in the evening, which I should have preferred. The heights are expressed in inches and hundredths of lines of the French foot, and are not yet reduced to the temperature of zero.

computed from the *maximum* of the morning, and the *minimum* of the afternoon. The extent of the variations were the same in the hottest months (January and February), and in the coldest (June and July).

MEAN OF THE BAROMETER AND THERMOMETER AT RIO JANEIRO.

MONTHS OF THE YEAR 1785.	at 10h in the morning		at noon		at 4h in the afternoon		at 10h at night		Apparent difference of 10h in the morn. and 4h in the aftern.
	Bar.	Th.	Bar.	Th.	Bar.	Th.	Bar.	Th.	
	in. l.		in. l.		in. l.		in. l.		l.
January	28 2.22	81.1°	28 1.96	81.7°	28 1.26	83.6°	28 2.30	81.7°	0.96
February	28 2.12	79.4	28 1.86	80.7	28 1.30	81.9	28 2.15	80.5	0.82
March	28 3.18	76.1	28 2.88	76.8	28 2.28	77.4	28 3.00	76.3	0.90
April	28 4.00	75.5	28 3.38	75.6	28 2.97	78.4	28 3.89	77.7	1.03
May	28 4.74	69.9	28 4,26	71.2	28 3.88	73.5	28 4.60	73.4	0.86
June	28 4.77	67.3	28 4.34	68.7	28 3.93	71.0	28 4.55	70.0	0.84
July	28 4.65	66.7	28 4.30	68.0	28 3.69	70.4	28 4.40	69.6	0.96
August	28 5.06	71.1	28 4.68	72.5	28 4.18	74.7	28 4.73	73.7	0.88
September	28 4.22	71.6	28 3.89	73.1	28 3.33	73.9	28 4.13	72.4	0.89
October	28 2.56	73.6	28 2.22	75.1	28 1.67	76.5	28 2.50	73.7	0.89
November	28 1.68	76.2	28 1.38	77.6	28 0.93	77.8	28 1.73	75.4	0.75
December	28 1.38	78.3	28 1.18	79.8	28 0.47	80.6	28 1.44	77.8	0.91
Mean	28 3.38	72.2	28 3.11	77.5	28 2.48	76.6	28 3.28	75.2	0.89

The first naturalists * who remarked the great regularity of the ascending and descending movement of the barometer within the tropics, were struck with the inequality which they observed in the extent of the variations between two consecutive days, alike calm and serene. It happens, for instance, that the column of mercury attains a greater height than usual at the hours of the *maximum* of the evening; that it diminishes very little during the night and till 4^h in the morning; that the barometer rises much more from 4^h till 9^h in the morning than it descends from 9^h in the morning till 4^h in the afternoon, and that this play of unequal movements continues during several days. A general tendency is then observed †, to the increase or diminution of the column of mercury, without the periodicity or alternancy of the variations being disturbed. They are

* *Literary Journal of the Hague*, 1722, p. 234. *Thibault de Chanvalon, Voyage to Martinique*, p. 135 (23).

† Within the tropics, this tendency modifies the extent of the horary variations, which remains the principal and most sensible phenomenon; in Europe, on the contrary, when the barometer has a general tendency to descend during several days, the lowering is simply slower, or stopped at the epochas of the *maxima*. The principal and most sensible phenomenon is then the tendency of the column of mercury to sink; and the atmospheric tides are manifested only by modifying it a little at the approach of the *limit-hours*.

two kinds of movements, which modify, and add to each other; and it may be said that the barometer remains lower one week than another in the torrid, as in the temperate zone. The knowledge of the limits of the *absolute maxima* and *minima* is very important for the measurement of heights by means of the barometer, whenever between the tropics, without corresponding observations, we deduce from a small number of observations made on a particular spot, and at certain hours of the day, the state of the barometer at every consecutive hour of day and night. Bouguer, La Condamine, and the greater part of the travellers who have spoken after them of horary variations, confound the extent of the oscillations corresponding to one atmospheric tide, with the changes of the mean heights of the barometer in different weeks or different months. Bouguer says * that the column of mercury in the torrid zone varies from $2\frac{1}{2}$ to 3 lines; but that the variations at Quito are only 1 line. The former part of this assertion can relate only to the extreme accidental

* *Figure de la terre*, p. 39. Caldas, in the *Semanario*, Vol. i, p. 248. Don George Juan thought he remarked a diminution in the extent of the oscillations, in proportion as he approached from the tropic to the equator (*Observ. Astronomicas*, p. 99). He fixes this extent at Petit Goave, lat. 21°, at 2 line, and at Guayaquil, at $1\frac{1}{4}$ line.

variations, and not to the extent of the variations during a whole tide. In reviewing the whole of my observations, made at different heights, and in latitudes more or less near the equator, it seemed to me that the extent of the variations diminishes very little with the elevation of the spot, and that it diminishes still less than the barometric mean of different days. At Cumana, La Guayra, Payta, Lima, and Rio Janeiro, at the level of the sea in both hemispheres, the mean extent of the oscillations or atmospheric tides is, at most, from 2.4^{mm} to 3 millimeters; and the difference of the absolute heights observed at the same hours of different days, amounts to 3, rarely to 4 millimeters *.

* A barometric height at the epocha of the *minimum*, not being compared with a height observed in another week, at the epocha of the *maximum*, the difference of the absolute heights at the same hours in different weeks, may perhaps be less than the extent of the horary oscillations. A traveller who would measure the height of a mountain by means of the barometer, without having corresponding observations on the coast, and who supposed the column of mercury to be invariable at Cumana (neglecting the consideration of the horary oscillations), and that of the difference of the absolute barometric heights, resulting from the accumulation of successive inequalities in the extent of the diurnal oscillations), would deceive himself sometimes in 6 millimeters; for I saw the barometer, July 18th, at 11^h in the morning, at 337.9^{li}, and August 30th, at 4^h in the afternoon, at 335.7^{li}. Colonel Lanz found the barometer at La Guayra, at noon, 26th Fe-

The extent of the horary oscillations at Lima (lat. 12° 2′ south), appeared to us a little less (1.7 to 2.3), than near the equator (2.6 to 3.3), in the forests of Atabapo and of Rio Negro.

bruary, 1822, at 0.76603m (th. 25°) cent.); February 28th, at 0.76510m (th. 26.5°); March 1st, at 0.76465m (th. 26.5°); and March 5th, at 0.76325m (th. 26.6°). If the relative correction of the horary variations be not neglected, there remains only, as a source of error in the measurement of mountains, without a corresponding observation, in the tropics, the difference of absolute barometric heights; and in distinguishing between the difference of extreme dispersion and the oscillations of that dispersion around the mean barometric height, we may conceive that the probable limit of the error arising from the cause we discuss, will rarely be above fifteen or twenty metres. This estimate is important for those who, in the barometric levellings projected for examining provisionally the isthmusses of Huasacualco, Darien, and Panama, may employ only one barometer. In order to know exactly the number of locks which a canal requires, we must, even between the tropics, where every circumstance is so favorable to the use of the barometer for the levelling of the soil, employ two instruments: the one should remain on the seashore, or, which is preferable, should follow the second barometer from station to station, as in the levelling operations executed by MM. de Parrot and Engelhardt, between the North and Caspian Seas. If, on the contrary, we seek only to know approximately (at about twenty metres) the height of the *ridge of partition*, which presents a favorable chance for *cutting an isthmus*, one barometer will suffice, which must be observed in going and returning, as ought always to be done in the *chronometric measurement* of distances.

In ascending from the coast of Venezuela on the table-land of Bogota, the difference of the diurnal *maxima* and *minima*, (notwithstanding the difference of 1365 toises of height), diminishes only one-fourteenth, and consequently, not in the relation of the barometric heights of the places we compare. The comparison of the same hours on different successive days furnishes at Santa Fe de Bogota *, and at Popayan (911 t.), scarcely the difference of three or four millimeters in the space of a whole year. The following tables prove, that a great equality in

* See *Semanario de Bogota*, Tom. i, p. 50, 83, 115, 177, 216, 255, 290. I calculated for every day the mean height of the barometer, and by the diurnal oscillations the extended mean of the oscillations in whole months; the results are marked in hundredths of lines of the French foot. M. Caldas announces in an indirect manner (*Semanario*, Tom. i, p. 55), that the *epochas of the limits, or tropical hours*, which I published in my *Essay on the Geography of Plants*, are not those which M. Mutis found on the plains of Bogota; this doubt does not appear to me to be well founded. MM. Boussingault and Rivero have confirmed the epocha of the *maxima* and *minima* which I had announced; and even M. Mutis, who is accused of not being very communicative, told me, when I shewed him my registers, "that the periods observed at Cumana were nearly conformable to those resulting from his researches, but that in the hottest days, the *maximum* was attained at Santa Fe de Bogota, at 8^h in the morning." This latter observation recalls the difference of the tropical hours remarked in Europe, by MM. Ramond, Marqué Victor, and Billiet, between the hottest and coldest seasons. (*See* above, p. 719).

the extent of every tide, produces on the back of the mountains, a surprising uniformity in the mean barometric heights of the months. I shall here present successively the results of the observations made on the same spot (at Santa Fe de Bogota), in 1807 and 1818, by M. Caldas, and in 1823 and 1824, by MM. Boussingault and Rivero. The latter, made with much more exact instruments, merit the highest confidence. M. Caldas finds for the twelve months of the year 1807:

	MAXIMA.	MINIMA.	DIFFERENCE.
January	247.23	247.60	0.65
February	249.33	248.33	1.00
March	249.33	247.93	1.40
April	249.42	247.92	1.50
May	249.67	248.00	1.67
June	249.67	248.00	1.67
July	249.50	247.83	1.67
August	249.42	247.92	1.50
September	249.42	248.00	1.42
October	249.33	247.91	1.42
November	248.92	248.00	1.92
December	248.85	247.60	1.15

The mean of 642 barometric heights, observed by the same naturalists, from January to July in the year 1808, presents the following results:

MEAN OF THE HORARY VARIATIONS OF SEVEN MONTHS ON THE TABLE-LAND OF BOGOTA.

MONTHS.	BAROMETRIC MEAN OF		EXTENT OF THE OSCILLATIONS.	MEAN TEMPERATURE OF THE MONTHS.
	MAXIMA.	MINIMA.		
January	249.04	247.99	1.05	13.2° R.
February	248.90	247.95	0.95	14.6
March	249.02	248.03	0.99	13.7
April	249.04	248.04	1.00	14.2
May	249.20	248.22	0.98	13.8
June	249.17	248.28	0.89	13.8
July	249.12	248.17	0.95	14.2

M. Caldas having published the mean temperature of every day, and the *maxima* and *minima* of the temperature of whole months, but not the temperature from 9h in the morning till 4h in the evening, the barometric heights of 1807 could not be reduced to the freezing point.—The case is the same with respect to the diurnal observations from January to July 1808. It may, however, be admitted, that the mean temperature of 9h in the morning (on the table-land of Bogota) is nearly 1.2° lower of the centigrade thermometer, and the mean temperature of 4h in the afternoon 1.8° higher than the mean temperature of the month.

MEAN HEIGHTS OF THE DAYS, AND EXTENT OF THE DIURNAL OSCILLATIONS ON THE TABLE-LAND OF BOGOTA.

JANUARY, 1808.	Mean barometric heights.	Extent of the oscillations.	Mean temperature Reaumur.	JANUARY.	Mean barometric heights.	Mean temperature Reaumur.	Extent of the oscillations.	JULY, 1808.	Mean barometric heights.	Extent of the oscillations.	Mean temperature Reaumur.	JULY.	Mean barometric heights.	Extent of the oscillations.	Mean temperature Reaumur.
1	248.33	1.34	14.1°	16	248.58	1.16°	12.3	1	248.62	0.75	14.5°	16	248.50	1.00	14.4°
2	248.29	1.42	14.0	17	248.58	0.83	12.9	2	248.50	1.00	14.6	17	248.50	1.00	14.5
3	248.29	1.42	13.9	18	248.58	0.83	13.2	3	248.75	1.00	14.1	18	248.83	1.00	13.0
4	248.33	1.15	13.1	19	248.75	1.00	11.8	4	248.45	0.75	14.5	19	249.00	1.00	14.0
5	248.50	1.00	14.0	20	248.50	1.00	12.1	5	248.45	0.91	14.5	20	249.00	1.00	14.0
6	248.16	1.00	14.4	21	248.75	1.00	12.8	6	248.58	1.00	14.3	21	248.87	0.75	14.2
7	248.16	1.00	15.2	22	248.75	1.00	12.9	7	248.83	1.00	13.8	22	248.79	0.92	14.0
8	248.24	1.17	12.8	23	248.49	0.83	13.0	8	248.75	1.00	14.0	23	248.83	1.00	14.0
9	248.12	0.92	12.8	24	248.87	1.25	12.1	9	248.37	0.75	15.0	24	248.87	0.75	13.4
10	248.41	0.83	13.0	25	249.00	1.00	13.4	10	248.37	0.75	14.6	25	248.87	0.75	14.1
11	248.55	1.10	12.0	26	248.70	1.25	15.9	11	248.83	0.67	15.0	26	248.50	1.00	15.0
12	248.55	1.10	12.0	27	247.87	1.75	13.8	12	248.62	1.09	14.5	27	248.50	1.00	14.2
13	248.41	0.83	13.5	28	248.41	0.83	13.9	13	248.37	0.75	15.5	28	248.67	1.00	14.5
14	248.75	1.00	14.6	29	248.70	0.75	13.9	14	247.91	0.83	15.0	29	248.75	1.00	13.0
15	249.08	0.84	15.7	30	248.79	0.75	13.8	15	248.50	1.00	14.3	30	248.75	1.00	14.0
				31	248.50	1.00	11.9					31	248.75	1.00	13.6

In examining for seven months the mean barometric height of the days, observed by M. Caldas, I find the least height to be 247.8^{li}; and the greatest 249.0^{li}. This difference of 1.2^{li}, or 2.7^{m}, is the effect of small inequalities of diurnal oscillations which accumulate by degrees. It was 3.12^{mm}, in the observations of M. Boussingault. Once only the extent of the variations of the day was but 0.63^{mm}; and once only it rose to 3.64^{mm}. In comparing the observations day by day from 9^{h} in the morning till 4^{h} in the afternoon, I find that in the observations of M. Caldas, the variations at 9$_{h}$ were from 248.30$_{li}$ to 249.50^{li}; and at 4^{h} from 247.00^{li} to 248.66$_{li}$; whence result the differences for 9^{h}, of 2.7^{mm}, and for 4^{h}, 3.6^{mm}. The labors of M. Boussingault give for those two limit-hours, 4.6^{mm} and 4.21^{mm}. «The limits of the accidental oscillations round the mean of the same hours, were consequently nearly the same at 1365 toises of height, as at the level of the equinoxial sea; but those extreme limits appear to me to be much more rarely attained on the back of the Cordilleras. The new observations of MM. Rivero and Boussingault, made with excellent barometers of Fortin, furnish the most certain notions hitherto obtained on the laws we have just discussed. They yield, for the mean extent of the oscillations, from 9^{h} in the morning till 4^{h} in the afternoon 2.29^{mm} (reducing the barometric heights to the temperature of zero.)

MAXIMA AND MINIMA OF DAYS OBSERVED ON THE TABLE LAND OF BOGOTA.

AUG. 1823.	BAROMETER at 9h in the morning.	BAROMETER at 4h in the afternoon.	DIFFERENCE.	AUG. 1823.	BAROMETER at 9h in the morning.	BAROMETER at 4h in the afternoon.	DIFFERENCE.	DEC. 1823.	BAROMETER at 9h in the morning.	BAROMETER at 4h in the afternoon.	DIFFERENCE.	DEC. 1823.	BAROMETER at 9h in the morning.	BAROMETER at 4h in the afternoon.	DIFFERENCE.
1	561.18	559.46	1.72	16	561.94	559.48	2.46	1	562.37	559.78	2.55	16	561.45	558.68	2.77
2		559.63		17	561.88	559.65	2.23	2	562.23	559.83	2.40	17	561.58	558.90	2.68
3	562.09	560.28	1.80	18	562.47	559.95	2.24	3	562.23	560.35	1.88	18	561.88	559.03	2.85
4	562.18	560.28	1.90	19	562.59	560.18	2.41	4	562.25	559.75	2.50	19	561.13	559.03	2.10
5	562.00	560.03	1.97	20	562.63	560.03	2.60	5	562.48	559.63	2.85	20	560.51	558.33	2.18
6	562.44	560.20	2.24	21	562.83	560.63	2.20	6	561.53	558.95	2.58	21	560.70	558.73	1.97
7	562.81	561.33	1.48	22	562.60	560.03	2.57	7	560.83	558.82	2.01	22	561.08	558.27	2.81
8	562.95	560.73	2.20	23	562.11	560.02	2.09	8	560.60	557.98	2.62	23	560.63	557.76	2.87
9	562.40	559.74	2.66	24	561.93	" "	" "	9	560.98	558.56	2.42	24	560.63	558.00	2.63
10	562.35	559.81	2.54	25	561.88	560.36	1.52	10	561.00	558.48	2.52	25	560.80	558.95	1.85
11	562.08	559.94	2.14	26	561.18	559.56	1.62	11	560.89	558.13	2.76	26	560.88	558.44	2.44
12	562.23	559.90	2.33	27	561.53	559.01	2 52	12	561.04	559.09	1.95	27	561.00	558.88	2.12
13	561.73	" "	" "	28	562.62	559.93	2.69	13	561.65	559.16	2.49	28	560.96	558.48	2.47
14	562.03	" "	" "	29	562.62	559.73	2.69	14	560.98	558.50	2.48	29	561.50	559.14	2.36
15	562.01	559.93	2.22	30	562.13	559.54	2.49	15	560.68	559.48	1.20	30	561.84	559.23	2.61
												31	562.38	559.90	2.48

At nine in the morning, on the 8th and 29th, violent hail, with thunder.

The heights of the barometer are in hundredths of millimeter. We shall choose two months only on the whole year, of which we are in possession. M. Boussingault justly observes, that "the mean monthly heights are greatest in June and July; and the least in December and January, when the earth is nearest the sun." The following are the mean heights reduced, as in the table of the month of August and December, to the temperature of zero. I have placed by the barometric mean, the mean extent of the diurnal oscillations from 9^h till 4^h, and the mean of the temperature corresponding to those epochas of the morning and afternoon. M. Ramond, from the year 1814, has thrown great light on the curious phenomenon of the monthly oscillations of the barometer.

MONTHLY MEAN OF THE BAR. AT BOGOTA (LAT. 4° 35′ 50″).				MONTHLY MEAN AT STRASBOURG (LAT. 48° 34′ 56″).		
RESULTS of a year.	MEAN BAROMETRIC heights.	MEAN of the oscillations.	MEAN TEMPERATURE from 9h till 4h	RESULTS of 14 years.	MEAN BAROMETRIC heights.	EXTREME DIFFERENCE of the max. and min.
January	0.56045m	2.31m	15.7°	January	333.128m	6.136m
February ...	0.56048	2.31	15.9	February	333.452	3.646
March	0.56061	2.39	15.3	March	332.905	4.573
April	0.56113	2.34	15.2	April	332.449	4.127
May	0.56075	2.45	15.4	May	332.516	1.964
June	0.56124	1.86	15.1	June	333.416	2.563
July	0.56134	1.50	14.2	July	333.168	2.385
August	0.56111	2.22	16.6	August	333.352	1.201
September ...	0.56094	2.59	16.2	September	333.633	2.471
October	0.56071	2.77	15.3	October	332.981	4.163
November ...	0.56045	2.44	15.1	November	332.866	5.376
December ...	0.56013	2.40	15.0	December	332.700	3.881

The movement of the barometer at Bogota is of surprising regularity; the mean heights acquire their *minimum* at the winter solstice, augment till after the summer solstice, and again decrease, without presenting any other anomaly than that of the month of May. This new and curious remark, is owing to the observations of MM. Boussingault and Rivero, and which those able naturalists found confirmed by the observations of M. Caldas, made in 1807. In our temperate climates, at Strasbourg for instance, the observations of M. Herrenschneider, during fourteen years, (indicated in lines of the French foot, and reduced to 15° centigrade temperature,) prove that the monthly mean * is highest in September, and lowest in April; in general however, the mean heights from June to September exceed those from October to February. The extent of the extreme variations in Europe presents great regularity; it decreases from winter to summer.

In the town of Mexico †, although near the tropic, I have hitherto found the extent of the ho-

* Seven years have proved to M. Ramond (*Mem. de l'Inst.*, 1812, Tom. ii, p. 44) that the mercury is highest at Clermont, in January and June, and lowest in April and November.

† This phenomenon, which is very common at Vera-Cruz in the season of *Nortes*, was observed at Mexico (at 1168 t. high) once only in a great number of years. (*Antonio Gama*,

rary oscillations extremely uniform. At the same hours the barometric heights scarcely differ from 2 to 2½ millimeters during whole months. But sometimes the north winds, which are so impetuous in the gulph of Mexico, blow back the air as far as the table land of Anahuac, and suddenly raise the mercury. This blowing back caused the barometer to mount * on the 23rd March, 1783, at 10h at night, 264 lines, while the *minimum* of all the heights observed in the whole year (20th January, 1783) was 259.3ll. In deducting the effect of the periodical oscillations, the extreme variations attain at the same hour of the *maxima* and the *minima*, by a concurrence of accidental circumstances, at most 3.8ll or 8½ millimeters. We are surprised to see this constancy in the extent of the oscillations on a table land, where, in 19° 25′ of latitude, the thermometer descends in winter, between 4h and 5h in the morning, several

Dissertacion fisica sobre la aurora boreal del 14 Nov. 1789, p. 14). I saw the barometer of Mexico descend at the epocha of the *minimum*, to 258.2ll (therm. 22° cent.) I saw it highest at the hour of the *maximum*, 260ll, (therm. 18.8°).

* *Political Essay*, Vol. i, p. 83. During this blowing back of the air, which is borne towards the boreal regions of the south, the centigrade thermometer does not sink at Vera Cruz (in the lower layers of the atmosphere) lower than from 20° to 18°, and at most to 16.5°.

degrees below zero. The north winds on the eastern coast of Mexico, at Vera-Cruz, (lat. 19° 11') often interrupt suddenly the regularity of the horary variations, during 5, 6, and even 8 days; and make the mercury oscillate from 333 to 341 lines, (difference 18 millimeters). I have stated in another place the importance of which this phenomenon, studied by M. Orta, captain of the port of Vera-Cruz, in all its various modifications, is become for the safety of navigators, who would sail in these dangerous latitudes. By inspecting the barometer, the proximity of the tempest, its force and duration may be prognosticated with great probability. I saw in the possession of M. Orta, near 28,000 thermometric and barometric observations, made with excellent instruments of Dollond, at the port of Vera-Cruz, from 1791 to 1803, four times a day, at 6h in the morning, at noon, 4h in the afternoon, and 10h in the evening. I advised that indefatigable observer to send a mass of materials so valuable, (the most considerable perhaps that was ever collected within the tropics, on the same spot), to Europe, to be deposited in the archives of some learned society. It is to be feared that the calamities which the town of Vera-Cruz has recently suffered during the bombardment of the Castle of San Juan d'Ulloa, may have deprived the scientific world of the labours of M. Orta.

We see that in advancing in the plains and on the back of the Cordilleras, from the equator towards the tropics, the proximity of the temperate zone renders the barometric mean of the months more and more unequal, because the accidental causes begin to act with greater force. At the extremity of the northern torrid zone, at the Havannah (lat. 23° 8′), the mean barometric height of the months differs with respect to their general equality, very little from the mean height of the months at Rio Janeiro (lat. 22° 54′), which is situated near the extremity of the southern torrid zone. It is interesting to compare, from the excellent observations of MM. Dorta, Robredo*, and Ferrer †, the variations of the weight of the atmosphere in the vicinity of the two tropics. At Rio Janeiro‡ the extreme barometric mean of December and August; and at the Havannah, that of September and January, differ nearly 8 millimeters, while at Bogota, nearer the equator, the monthly mean does not swerve 1½ millimeters.

* *Observ. meteorologicas hechas en la Havana y en el pueblo de Ubajay* (manuscript).

† *Conn. des temps pour* 1817, p. 338.

‡ Rio Janeiro: mean height, bar. in December 1785, 337.02^{li} (th. 25.7° cent.); in August, 340.59^{li} (th. 22.1°); at the Havannah (1810—1812), in September, 761.23^{mm} (th. 28.8° cent.); in January, 768.09^{mm} (th. 21.1°). Reduced to the temperature of zero, the difference near the tropic of capricorn is, 8.3^{mm}: near the tropic of cancer, 7.9^{mm}.

HAVANNAH.—*Mean of the months during the years*, 1810-1812.

	Barometer.	Centigrade Thermometer.
January	0.76809m	21.1
February	0.76301	22.2
March	0.76428	24.3
April	0.76301	26.1
May	0.76199	28.1
June	0.76453	28.4
July	0.76453	28.5
August	0.76123	28.8
September	0.76098	27.8
October	0.76174	26.4
November	0.76453	24.2
December	0.76656	22.1
Mean of the year	0.76371	25.7

The least height of the barometer, during those three years, was at 25° of temperature, and in a furious wind from S.S.W. on the 25th October, 1810, it was 0.74472m; the greatest height was observed on the 20th of February, 1811, and was 0.77545m.: the difference of those two numbers (0.03073m), is the greatest barometric variation ever observed in that island. During the stay I twice made at the Havannah, my barometer rose (the temperature being the same), during the strong gales from N.N.E. 4 lines (9 millimeters) more than in

the tempestuous winds from the south *. The meteorologic journal of M. Robredo proves that these differences are alike remarked far from the coast, in the interior of the island. It is not the mean of the months that differs more near the tropic of cancer than near the tropic of capricorn, it is rather the extreme heights owing to accidental causes. At the boundary of the southern torrid zone, the extreme oscillations † of the barometer attain only 21 millimeters (9.3li) ; at the extremity of the northern torrid zone, they are often 25 millimeters, sometimes 30.5mm (13.3li). The southern hemisphere, south of the parallel of 23°, contains a very small portion of land ; and the atmosphere

* The hurricanes are not in general accompanied by such an extraordinary lowering of the barometer as is imagined in Europe. I possess 56 barometric observations made by the captain of a ship, Don Tomas de Ugarte, nearly from hour to hour, at the Havannah, during the terrible hurricane of the 27th and 28th of August, 1794. When the tempest was most violent, the column of mercury sunk only 5 lines (11.3mm). Kirwan asserts however, that at the island of Saint Bartholomew, the barometer has been seen to lower in a hurricane (1792), 42 millimeters. *Irish Trans.*, vol. viii, p. 387. Is this fact as well certified as a lowering of 25 millimeters at the Isle of France? (*Moreau de Jonnès, Hist. phys. des Ant.*, Tom. i. p. 420). See on the barometric heights observed on the coast of Chili, *Espinosa, Memorias de los Naveg. Esp.*, Tom i, p. 129, 134, 179.

† In December and March. See *Mem. de Lisboa*, Tom. ii. p. 397.

for that reason, is less violently agitated than in the northern hemisphere.

Almost on the parallel of the Havannah, but 164° more to the west, at Canton and Macao in China, the extent of the horary oscillations presents nearly the same constant equality: the mean of the months differ* 7½ millimeters; but the greatest variation observed during a whole year on the same day, (January 15th 1814), was only 4 millimeters.

At Cairo, where (as in the Canary Islands), the mean horary variations do not rise above 0,5li or 0.8li (1.10mm or 1.76mm), the extreme variations are inconsiderable, and scarcely differ from those which M. Dorta observed at Rio Janeiro. M. Coutelle† saw the column of mercury vary only 22 millimeters in the course of three years, from the effect of accidental perturbations. These limits of perturbation approach

* I find from the manuscript journal of the M. l'abbé Richenet, the mean of the twelve months of the year 1814, at Macao, as follows: 30.34li (th. 68° Fahr.); 30.30 (th. 65°); 30.26 (th. 66°); 30.11 (th. 71°); 30.11 (th. 74°); 29.96 (th. 81°); 29.99 (th. 83°); 29.99 (th. 83°); 30.15 (th. 80°); 30.19 (th. 78°); 30.28 (th. 72°); 30.35 (th. 62°). Mean of the year 30.17li (th. 74°). The scale is in English inches. The barometric heights are not reduced to the temperature of zero.

† At Cairo, January 3rd 342.0li (th. 5.5° R.); January 16th, 335.5li (th. 10). Difference reduced to the temperature of zero, 15.41mm.

nearer than at the Havannah, in the system of American climates.

The diminution in the extent of the horary variations, in advancing from the equator * towards the pole, was remarked by M. Ramond † as soon as he began to compare the results of his observations at Clermont-Ferrand with those which I had collected in the torrid zone. "The extent of the variations," says this able naturalist, "is half less in France than between the tropics. The *maximum* of the variations in our climates is in spring: the ascent of the day in Europe is nearly equal to the preceding lowering, while in the tropics

* At Senegal (lat. 15° 53′) a well-informed traveller M. de Beaufort, found recently, by means of observations that comprehend two months and a half, the extent of the horary oscillations to be 2.7mm. He gives for 7h in the morning 0.7629m (th. 21°); for noon 0.7654 (th. 25°); for 4h in the afternoon, 0.7663m (th. 23°); and for 8h in the evening, 0.7667m (th. 19°). Reduced to the temperature of zero, the observations of noon, and at 4h in the afternoon give, 0.7619m, and 0.7631m, and not, as is asserted in a letter addressed to M. Jomard (January 25th 1824), 0.7631m, and 0.7658m. (*Bulletin de la Soc. de Géographie*, p. 14, 59). *Hertha*, 1825, n. 3, p. 143. These observations little accord with what has been found in every other part of the earth, where the barometer has every where been seen lower at 4h in the afternoon, than at 8h in the morning, and at noon.

† *Mém. de l'Institut*, 1808, p. 107, and 1812, p. 46.

these quantities differ from single * to double." M. Arago, whose meteorological observations already comprehend 9 years, and who disposed them in such a manner as to place most in evidence the value of the diurnal variation † of the barometer, finds, that the descending oscillation at Paris, from 9^h in the morning till 3^h in the afternoon, is only 0.8^{mm} (0.35^{li}); and that in reducing all the heights to the same temperature, the mean of 15 to 20 days suffices, at all seasons, to ascertain the existence and movement of the horary oscillations ‡. We have seen that the mean of the barometric

* According to my first view, the type of the movement of the barometer, on the shore of the equinoctial sea, appeared to me as follows: the mean barometric height at 8^h in the morning, will give, $h + 0.5^{li}$; at 4^h in the afternoon, $h - 0.4^{li}$; at 11^h at night, $h + 0.1^{li}$; at 4^h in the morning, $h - 0.2^{li}$. It results from this hypothesis, for 9^h in the morning, 338.30^{li}; for noon, 338.02^{li}; for 4^h in in the afternoon, 337.40^{li}; for 11^h at night, 337.91^{li}; for 4^h in the morning 337.60^{li}. See my *Essay on the Geogr. of Plants*, p. 91, and my *Rec. d'Obs. astr.*, vol. i, p. 286, 289.

† See the important discussions in the *Annales de chimie et de physique*, Vol. iii, p. 442; Vol. vi, p. 439; Vol. ix, p. 426; Vol. xii, p. 421; Vol. xv, p. 416; Vol. xviii, p. 407.

‡ It is to be regretted that the observations at Paris and Geneva cannot be compared, the latter containing no element that serves to make known the horary observations. (*L. c.*, Vol. vi, p. 440).

heights of the months, differs 1.2^{mm}, near the equator, and 8^{mm}, near the tropics of cancer and capricorn (at Rio Janeiro and the Havannah). At Paris (lat. 48° 50′) the monthly mean generally varies from 8 to 9 millimeters* in one year. The compensation of these accidental variations is such, that at the center of temperate Europe, one month suffices to approach at least $\frac{1}{8}$ nearer the mean value of the barometric heights, than that which we find on the confines of the equinoctial and temperate zone †.

M. Marqué Victor found at Toulouse (lat. 43° 35′) the mean of the extent of the horary oscillations, 1.2^{mm}; he remarked no connection

* I wish I could compare Paris with some spot placed in the same latitude, on the eastern coast of America; but we have hitherto no precise observations on the horary variations of the barometer, except those which an observer full of zeal, M. Jules Wallenstein, has lately made at Washington (lat 38° 55′), where the mean temperature (14.7° cent.) is 4 degrees above the mean temperature of Paris. The barometric heights of the different months varied at Washington in 1824, 14.8^{mm}, or 6½ lines; which proves how much the atmosphere is subject to great variations, on the *eastern coast* of the United States. (*Amer. Trans.*, 1824, p. 7).

† In some years it has happened that the barometric mean of the months has differed less at Paris than at Rio Janeiro, and the Havannah. This difference was only from 5½ to 6½ millimeters, in 1816 and 1819.

between the greatness of the horary oscillations, and the seasons *; but this connection is manifest at Paris by the mean of 72 months. The extent of the oscillations from 9^h in the morning till 3^h in the afternoon, was found, in the months of November, December, and January, to be only 0.54mm; and in the three following months, † 1.05mm. The same difference is manifested in the observations made by M. Ramond, at Clermont-Ferrand. M. Billiet found in 1822 and 1823, the extent of the horary variations at Chambery (lat. 45° 34′) to be in winter, 0.90mm and 0.82mm; and at the same epocha, at Paris, 0.69mm and 0.73mm. On the contrary, in the summer months of 1822, and 1823, these quantities attained at Chambery, 1.29mm and 1.00mm; and at Paris, 0.90mm and 0.75mm. The two whole years which we take for an example, give‡ for Chambery, 1.06mm;

* *Bibl. univ.*, Tom. xx, p. 246.

† *Laplace, Essai phil. sur les probabilités*, 1825, p. 122.

‡ These differences, which we find in reducing all the observations of Paris, Chambery, and Toulouse, to the temperature of zero, are so much the more remarkable as the latitude differs only 5°, and the accidental variations observed at the same hours at Chambery, are $\frac{1}{4}$ less than at Paris. M. Marcel de Serres asserts that he found for one year only (1819), reducing the heights to the temperature of zero, the extent of the oscillations at Montpellier, 1.67mm. M. Arago obtained in the same year, 0.33mm, for Paris. *Bullet. de la Soc. d'Agr. du Hérault. Sept.* 1824.

for Paris, scarcely 0.78^{mm}; for la Chapelle, near Dieppe, 0.36^{mm}. I know of no precise or numerous observations for the latitude of 60°; but M. Bessel has published a very important result which corresponds to the parallel of Kœnigsberg (lat 54° 42′), where the mean of eight years of observations made by M. Sommer with the same instrument, and reduced to the temperature of 10° cent. gives, for 8^{h} and 9^{h} in the morning, 337.351^{li}; for 2^{h} and 3^{h} in the afternoon, 337.264^{li}; and for 9^{h} and 10^{h} in the evening, 337.351^{li}. The extent of the horary oscillations is therefore at that high latitude, only 0.087^{li} (scarcely the one-tenth of a millimeter), or 4 times less than at Paris. M. Bessel adds, that those observations at Kœnigsberg are so precise, that, notwithstanding the smallness of the oscillations, the value of the horary variation is ascertained in the mean of each year †.

The mean height of the hour of noon at Paris, scarcely differs in a whole year, according to the remark of M. Arago ‡ one-tenth

* Mean of four years (from 1819 to 1822). The smallness of the oscillations perhaps depends, according to M. Arago, on the elevation of the spot, which is not a table-land. M. Nell de Bréauté, in the *Bibl. univ.*, Tom. xxii, p. 105.

† *Schumacher, Astron. Nichrichten*, 1823, p. 26.

‡ *Annales de Chimie*, Tom. ix, p. 428. M. Billiet finds that at no season, at Chambery, the mean of noon differs ½

of a millimeter from the mean height determined by the observations of 9^h in the morning, and 3^h in the afternoon. M. Herrenschneider observes that in 16 years (1807-1822), the barometric mean of noon differed only 1.8^{mm}; and the general barometric mean of Strasbourg only one-fortieth of a millimeter. The following table presents the results of nine years made at the royal observatory of Paris:

YEARS.	MEAN of 9^h in the morning.	MEAN of noon.	MEAN of 3^h in the afternoon.
1816	754.13	753.94	753.45
1817	756.48	756.16	755.69
1818	756.11	755.81	755.22
1819	755.07	754.85	754.35
1820	756.10	755.85	755.37
1821	756.04	755.83	755.36
1822	757.48	757.17	756.65
1823	755.04	754.78	754.29
1824	755.78	755.54	755.05
Mean of 9 years.	755.80	755.54	755.08

of a millimeter from the mean of the month. (*Bibl. univ.*, Feb. 1824, p. 93). See an excellent memoir on the horary variations observed at Strasbourg by M. Herrenschneider, among those of the *Society of Sciences at Strasbourg*, vol. ii. p. 403.

I have added in the preceding pages a great number of unpublished materials to those dispersed in different works. I shall conclude this task by indicating the laws, or rather the most general relations, which the singular phenomenon of the small atmospheric tides presents:

1° The horary oscillations of the barometer are felt in every part of the earth, in the torrid, as well as in the temperate and frigid zones, at the level of the sea as well as at elevations exceeding 2000 toises. These oscillations are periodical, and every where composed of two ascending and descending movements. The two atmospheric tides are not in general of equal duration *. In comparing results of unequal exactness, and obtained by thirty observers, between 25° of south latitude and 55° of north, we find differences of 2 hours for the epochas of the *maxima* and the *minima*: in excluding five results only, the *maximum* of the morning falls between $8\frac{1}{2}^h$ and $10\frac{1}{2}^h$; the *minimum* afternoon, between 3^h and $5^h\frac{1}{2}$; the *maximum* of the evening between 9^h and 11^h, and the *minimum* between 3^h and 5^h in the morning. It is to be presumed that those limits will be found to be drawn much nearer when a

* See the *Table of the general statement of the horary observations.* The result most generally is, for the duration of the ascending and descending tides, between the tropics, $6\frac{1}{2}^h$, 6^h, 6^h, and $5\frac{1}{2}^h$.

greater number of observations of equal precision are made for the different zones. Provisionally, we may adopt as the type most generally recognized of *maxima* and *minima*; in the equatorial zone: + $21\frac{1}{4}^h$; — 16^h; + $10\frac{1}{2}^h$; — 16^h. In the temperate zone: + $20\frac{1}{2}^h$; — $3\frac{1}{2}^h$; + $9\frac{1}{2}^h$; — 14^h, astronomical time, reckoned from noon.

2°. In the temperate zone the epochas of the *maximum* in the morning and the *minimum* of the evening, are one or two hours nearer the passage of the sun over the meridian in winter than in summer; but the type of summer is that which most resembles the type observed between the tropics. Observations are wanting above all, for the *minimum* which takes place after midnight; it were to be wished that the influence of the variable epocha of sunrise, on the hour of the morning *minimum*, could be examined.

3°. In the torrid zone, the limit-hours (that is, the instants when the oscillations attain the *maximum* and the *minimum*), are the same at the level of the sea, and on table-lands at the elevation of from 1300 to 1400 toises. It is asserted that this isochronism is not manifested in some parts of the temperate zone, and that at the convent of the Great Saint Bernard, for instance, the barometer lowers at the same hours when it rises at Geneva. If this pheno-

menon be general * in Europe, it remains to be

* Some observations made in Europe in the hollows and on the declivity of mountains, and the supposition of the displacing of the air in the layers superposed on each other, have led some naturalists to believe that the *maxima* and the *minima* could not coincide at la Guayra and Caraccas; on the coast of the South Sea (for instance at Payta), and at Popayan, or Santa Fe de Bogota; at Vera Cruz and at Mexico; on the coast of Malabar, where M. Horsburgh observed, and on the plains of the Mysore and of Nepaul. The preceding tables prove that these doubts are altogether unfounded with regard to the table-lands situated between the tropics. The observations of M. Ramond, made at the height of 210 toises, at Clermont-Ferrand, give us a right to suppose, from analogy, that in the elevated plains of La Mancha, in Spain, at 320 toises, we should see the barometer ascend at the same hours as at Valencia or Cadiz. We have already mentioned, that the observations at Saint Bernard and Geneva, were made at two periods of the day the least fitted to shew us the oscillations of the mercury, at the variable hour of sun-rise, and the fixed hour of two in the afternoon. These periods precede unequally the *maxima* and the *minima*. In the observations at Geneva the barometer is at sunrise, in winter as in summer, a little higher than at two in the afternoon; but at Saint Bernard, during the twelve months of the year 1824, the mean of sunrise was five times lower (January, April, June, August, October) three times higher (February, May, July), and four times equal to the mean of two in the afternoon. (*Bouguer, Fig. de la Terre*, p. 39. *Deluc. Rech. sur les Modif. de l'Atm.*, § 528, 530, and 596. *Bibl. Univ. pour* 1820. *Juillet*, p. 196; Tom. x, p. 201. *Daubuisson, dans le Journal de Phys.*, Tom. lxxi, p. 24). In the rapid lowering of the barometer on the 22d of February, 1823, the *maximum* of the descent took

ascertained if it be produced on extended table-lands, as well as in *necks* or narrow passages.

4°. We see every where (as may be supposed) that the variations slacken near the concave and convex summits of the curve they represent; that is, when the barometric heights attain alternatively their *maximum* and their *minimum*; and in some parts of the earth the

place at the same hour at Saint Bernard and Geneva. (*Bibl. Univ.*, Tom. xxii, p. 111). These uncertainties on the isochronism of the oscillations can never be removed, till we possess the mean observations made at the *limit-hours*, for Geneva and Saint Bernard, Milan and the village of Simplon, and for Trento and Inspruck. It may also happen that the *necks* of land situated on the top of the Alps, and surrounded with lofty summits, retard and modify the periods of the *maxima* and the *minima*, and that this local influence ceases in table-lands of greater extent. In order to know if a want of isochronism is manifest in the torrid zone, in certain circumstances, I have recently engaged MM. Boussingault and Rivero to observe their barometers simultaneously at Santa Fe de Bogota, and at la Chapelle de Notre Dame de Guadaloupe, which seems as if it were fixed to a rock almost perpendicularly above the town, with a difference of height of 322 toises. Mr. Daniel (*Meteor. Essays*, 1823, p. 260), thought he recognized in the observations made during the last voyages to the polar regions, especially in Melville Island, and at the Rocky Mountains, that the barometer rises in 74° of latitude, when it falls in 41°. That learned naturalist appears to attribute this phenomenon to atmospheric currents, of which it is not easy to verify the existence.

mercury appears to remain stationary during a very considerable time. That time varies from 15′ to 2^{h}; and in determining with precision the *half-duration* of the stationary state, we should distinguish between the real instant of the *maximum*, and the epocha when the barometer ceases, as to our senses, to rise or fall.

5°. In the torrid zone in general, between the equator and the parallel of 15° north and south, the strongest winds, storms, earthquakes, the most sudden variations of temperature and humidity, neither interrupt nor modify the periodicity of the variations. This is the more worthy of attention, as in some parts of equatorial Asia, where the *monsoons* blow with violence, (for instance in India,) the rainy season entirely masks the type of the horary variations, and that at the same period when these variations are insensible in the interior of the continent, on the coast, and in the straits, they are manifested without any alteration within the same parallel, in the open sea.

6°. Between the tropics, one day and one night suffice to know the *limit-hours*, and the duration of the small atmospheric tides; in the temperate zone, in 44° and 48° of latitude, the phenomena of *periodicity* are manifested at all seasons with great clearness, in the mean of from fifteen to twenty days.

7°. The unequal extent of the diurnal varia-

tions in the torrid zone, produces, at the same hours of different months, more or less considerable differences of barometric height. The extent of the oscillations decreases in proportion as the latitude, and the annual variations, owing to accidental perturbations, augment. The mercury is generally a little less elevated in the *maxima* of the evening than in the *maxima* of the morning. If we confine ourselves to precise observations, sufficiently numerous to yield a mean worthy of belief, we find that the extent of the oscillations in the torrid zone, between the equator and the parallel of 10°, in the tide of from 9^h in the morning till 4^h in the afternoon, is, in the plains, 2.6^{mm} to 3.3^{mm} (p. 735); on the table-land of Bogota (1365 t.), 2.3^{mm} (p. 743); towards the extremity of the southern torrid zone, in the plains, two millimeters (p. 729). The diurnal oscillations vary in the whole year (at Bogota) from 0.63^{mm} to 3.64^{mm}; the mean of the monthly oscillations varies from 1.5^{mm} to 2.7^{mm} (p. 739-742). The extent of the oscillations in the morning tides (from 9^h till 4^h), and in the evening (from 4^h till 11^h), are generally in the tropics, in the relation of 5 : 4, or 5 : 3. The mean barometric heights of the day vary between 0° and 10° of latitude, in the plains, from 3.8^{mm}; and on the table-land of Bogota, three millimeters. A difference of 1400 toises of elevation influences, consequently,

but little the mean of the diurnal oscillations, and the extremes of those oscillations. The mean of the hour of noon between the tropics, is constantly (some tenths of millimeter) more elevated than the general mean of the day, taken from the *maximum* of 9^h in the morning, and the *minimum* of 4^h in the afternoon. In advancing from the equator towards the polar regions, we find the differences of the barometric heights from 9^h in the morning till 4^h in the afternoon; 0°-20° lat. 2.5^{mm} to 3.0^{mm}; 28°-30° lat. 1.5^{mm}; 43°-45° lat. 1.0^{mm}; 48°-49° lat. 0.8^{mm}; 55° lat. 0.2^{mm}.

8°. The monthly barometric means differ from each other, in the tropics, from 1.2^{mm} to 1.5^{mm}; and at the Havannah, Macao, and Rio Janeiro, near the tropics of cancer and capricorn, from seven to eight millimeters, nearly as in the temperate zone. The extreme variations of the year are at the same hours, near the equator, from four to four and a half millimeters; they sometimes rise to 21^{mm}, at the extremity of the equinoxial zone, near the tropic of capricorn, and to twenty-five and thirty millimeters near the tropic of cancer. The limits of the extreme monthly oscillations in the temperate climate of Europe, are in the ascending movement, half as near again to each other, as within the tropic of cancer: this difference between the two zones is much less sensible in the

limits of the descending oscillations. The interruption of the horary oscillations near the tropic of cancer (in the gulph of Mexico) is a prognostic of the proximity of tempests, of their force and duration. The monthly means of the barometric heights diminish regularly from July to December and January, on the table-land of Bogota (p. 739), and even in the southern hemisphere, on the coast of Rio Janeiro (p. 731). The blowing-back of the north winds at the extremity of the northern equinoxial zone, raises the mean of December and January, above that of July and August (p. 726 and 748.

9°. Within the tropics, as well as in the temperate zone, in comparing the extreme swerving of the barometer from month to month, we find the limits of the ascending oscillations two or three times nearer than the limits of the descending oscillations *.

10°. The observations hitherto collected have not indicated a sensible influence of the moon †

* According to the meteorological journal (manuscript) of M. Don Antonio Robredo, at the Havannah, the extreme oscillations in 1801, were, in the *maxima* of the months 30.16^{in} (angl. measure), and 30.41^{in}; in the *minima*, 29.52 and 30.38. Difference of the *maxima*, 5.28^{mm}: of the *minima*, 18.20^{mm}. At Paris and Strasbourg the extreme ascending oscillations do not vary more in different months, than from 10 to 12 millimeters; the extreme descending oscillations vary from 20 to 30 millimeters.

† *Laplace, Essai Phil. sur les probabilités*, 1825, p. 119,

on the oscillations of the atmosphere. Those oscillations appear to be owing to the sun,

123, 274; *Conn. des temps pour* 1825, p. 312. The influence of the lunar attraction would be more easily ascertained between the tropics, when the accidental perturbations mask so little the play of the horary variations. I watched several nights, without observing any thing satisfactory on this subject; but M. Mutis assures me he discovered that "at Santa Fe de Bogota the barometer mounts and descends most in the quadratures, while at the epocha of the oppositions and conjunctions, the difference of 11^h at night and $3\frac{1}{2}^h$ in the morning becomes extremely small." M. Caldas (*Semanario*, Vol. i, p. 55) mentions also this observation of his master. It were to be wished that the meteorological journals which M. Mutis kept during thirty to forty years, were carefully examined, if several of those precious manuscripts were not dispersed after his death, during the political troubles of New Grenada. M. Boussingault, who devotes himself with the same ardour to the examination of every physical phenomenon, has again gone over the labours of M. Mutis (employing much more perfect instruments) in the syzygies as well as the quadratures, at the hours of the passage of the moon over the meridian, but he could not ascertain the lunar influence on the barometric heights. He writes to me from Santa Fe de Bogota, (February 9th, 1825), "I dare not altogether deny," he writes, "the lunar influence on the mean height of the mercury, but I believe that if that influence exists, it is scarcely sensible, because it is lost among the other causes of the horary variations." Seeking to collect in this work whatever can throw light on the *Meteorology of the torrid zone*, I believe it will be agreeable to naturalists to find at the end of this memoir, a part of M. Boussingault's observations on lunar influence. It will be seen that the mean of the syzygies differs only 0.16^{mm}

which acts, not by its mass (by attraction), but as a *calorifying* orb. If the solar rays, in modifying the temperature, produce periodical changes in the atmosphere, it remains to be explained why the two barometric *minima* nearly coincide with the hottest and coldest periods of the day and night.

from the mean of the quadratures. Toaldo thought he had found by the mean of 40 years, and by employing a method little exact, that the barometer in Italy is higher in the quadratures than in the syzygies, in the apogee than in the perigee. (*De la Infl. degli astri*, 1761, p. 122. *Lambert, Act. Helv.*, Tom. iv, p. 123. *Journ. de Phys.*, 1799, *June*, p. 270.)

BAROMETRIC MAXIMA OF NINE IN THE MORNING (REDUCED TO THE TEMPERATURE OF ZERO) OBSERVED AT SANTA FE DE BOGOTA, BY MM. BOUSSINGAULT AND RIVERO, TO EXAMINE THE INFLUENCE OF THE SYZYGIES AND QUADRATURES ON THE HORARY VARIATIONS.

DAYS OF THE LUNAR PHASES.	NEW MOON.	FIRST QUARTER.	FULL MOON.	SECOND QUARTER.
August 6, 13, 21, 29, 1823 - -	0.56244^{m}	0.56173^{m}	0.36283^{m}	0.56262^{m}
September 4, 12, 20, 27 - - -	0.56237	0.56187	0.56283	0.56294
October 4, 12, 19, 26 - -	0.56221	0.56218	0.56108	0.56258
November 2, 10, 18, 25 - - -	0.56183	0.56148	0.56230	0.56215
December 2, 10, 17, 24 - - -	0.36233	0.56100	0.56158	0.56063
January 1, 9, 16, 23, 1824 - -	0.56205	0.56063	0.56171	0.56263
January 31, February 8, 14, 21 -	0.56192	9.56151	0.56082	0.56168
February 29, March 8, 15 - -	0.56248	0.56198	0.56228	. . . . .
March 30, April 13, 21 - - -	0.56164	. . . . .	0.56202	0.56312
April 29, May 6, 13, 20 - - -	0.56251	0.56263	0.56196	0.56241
May 28, June 4, 11, 19 - - -	0.56150	0.56168	9.56201	0.56163
June 26, July 3, 11, 19 - - -	0.56259	0.56103	0.56233	0.56198
Mean - - - - - - - - -	0.56216	0.56161	0.56198	0.56222

The first column indicates the days when the observations of 9h were nearest the epocha of the syzygies, and quadratures. In the temperate zone a decade often suffices to ascertain the periodicity of the atmospheric tides; but the preceding table renders it probable that within the tropics, twelve days of observations, the days of sizygies and quadratures, are not sufficient to disengage the lunar effect from accidental perturbations. More positive results would be obtained, if, after having collected a great number of observations made at the instant of the passage of the sun and moon over the meridian, the regular effects of the diurnal period were defalcated.

OBSERVATIONS OF HORARY VARIATIONS (NOT REDUCED TO THE SAME TEMPERATURE) MADE BY M. BOUSSINGAULT AT SANTA FE DE BOGOTA, IN 1824, TO EXAMINE THE INFLUENCE OF THE PASSAGE OF THE MOON OVER THE MERIDIAN ON THE OSCILLATIONS OF THE BAROMETER.

January 3	9h	0.56300m	Temp. of B. 14.5°C.
	10	0.56265	16.5
	11	0.56225	16.3
	noon	0.56180	16.5
	1	0.56095	16.5
	2	0.56005	16.5
	3	0.55957	16.3
	4	0.55955	16.2
	11	0.56190	16.0
January 4	4	0.56070	16.2
January 5	5	0.56100	16.1
	9	0.46275	16.2
	10	0.56275	16.3
	11	0.56265	16.5
	noon	0.56230	16.8
	1	0.56160	16.2
	2	0.56125	16.2
	3	0.56080	16.5
	4	0.56050	16.2
	5	0.56065	16.4
	6	0.56110	16.3
	7	0.56155	16.8
	9	0.56260	16.5
	10	0.56275	16.8
	11	0.56245	16.8
January 6	8½	0.56315	16.2
	9	0.56300	16.1
	10	0.56295	16.1

« on the merid. 1h 49′

« on the merid. 3h 11′

OBSERVATIONS OF HORARY VARIATIONS BY M. BOUSSINGAULT, AT SANTA FE DE BOGOTA *(Continuation)*.

January 6	1h	0.56255m	Temp. of B.	16.2°C.
	noon	0.56205		16.5
	1	0.56155	☾ on the merid.	16.5
	2	0.56115		16.5
	3	0.56080		16.3
	4	0.56070		16.5
	5	0.56070		16.2
	10	0.56255		15.8
	11	0.56255		15.8
January 7	4	0.56145	3h 52′	15.9
	7	0.56275		16.0
	8	0.56300	☾	16.1
	9	0.56300	on the merid.	16.0
	10	0.56295		16.1
	11	0.56260		16.0
	noon	0.56220		16.1
	1	0.56190		16.2
	2	0.56120		16.2
	3	0.56095	4h 33′	16.2
	4	0.56090		16.0
	5	0.56095		16.0
	6	0.56110	☾	16.1
	10	0.56245	on the merid.	16.0
	11	0.56240		16.0
January 8	noon	0.56145		16.0
	4	0.56015		15.9
	5	0.56050		16.0
	6	0.56075		16.1
January 9	9	0.56220	5h 14′	15.9
	4	0.55965		16.1

RESULT OF THE OBSERVATIONS OF THE HORARY VARIATIONS MADE BETWEEN THE PARALLELS OF LATITUDE 25° SOUTH, AND 55° NORTH, FROM THE LEVEL OF THE OCEAN TO THE ELEVATION OF 1400 TOISES.

ZONES.	Names of the observers.	LIMIT-HOURS. Minima after midnight.	Maxima of the morning.	Minima afternoon.	Maxima of the evening.	Mean extent of the oscillations of the barometer (in hundredths of millim.)	PLACES OF OBSERVATION.
EQUATOR.	Lamanon & Mongès.	— 4h	+ 10h	— 4h	+ 10h	....	Equatorial and Atlantic Ocean.
	Humboldt & Bonpland.	— 4½h	+ 9¼h	— 4½h	+ 11h	2.55	Equatorial America, from 23° N. lat. to 12° S. lat between 0° and 1500 toises of elevation.
	Duperrey.	— 3h	+ 9h	— 3¼h	+ 11¼h	3.40	Payta (on the coast of Peru), lat. 5° 6′ south.
	Boussingault & Rivero.	....	+ 9¼h	— 3½h	+ 10h	2.44	La Guayra, lat. 10° 36′ N.
		— 4h	+ 9h	— 4h	+ 10h	2.29	Santa Fe de Bogota (lat. 4° 35′ N.) height 1366 t.
	Horsburgh.	— 4h	+ 8½h	— 4h	+ 11h	....	Indian and African sea (lat. 10° N., 25° S.
	Langsdorff & Horner.	— 3½h	+ 9¾h	— 4h	+ 10½h	....	Equatorial Pacific Ocean.
	Sabine.	— 5h	+ 9½h	— 3¾h	+ 10h	....	Sierra Leone, lat. 8° 30′ N.
	Kater.	— 5h	+ 10½h	— 4h	+ 10½h	....	Table-land of Mysore, (lat. 14° 11′ N. height 400 t.) Rainy season.
	Simonoff.	— 3½h	+ 9½h	— 3½h	+ 9¾h	....	Pacific Ocean, from lat. 24° 30′ N. to 25° 0′ S.).
	Richelet.	— 5h	+ 9h	— 5h	+ 10h	....	Macao, lat. 22° 12′ N.
	Balfour.	— 6h	+ 9¼h	— 6h	+ 10h	....	Calcutta, lat. 22° 34′ N.
	Dorta, Freycinet, Eschwege.	— 3h	+ 9½h	— 4h	+ 11h	2.34	Equinoxial Brazil, at Rio Janeiro (lat. 22° 54′ S.), and at the Missions of the Coroados Indians.
	Hamilton.	....	....	....	....	....	Table-land of Katmandoo (in India), lat. 27° 48′ N.

North and South Torrid Zone.

3 E 2

771

RESULT OF THE OBSERVATIONS OF THE HORARY VARIATIONS MADE BETWEEN THE PARALLELS OF LATITUDE 2° SOUTH, AND 55° NORTH, FROM THE LEVEL OF THE OCEAN TO THE HEIGHT OF 1400 TOISES. *(Continuation.)*

ZONES.	Names of the Observers.	LIMIT-HOURS. Minima after midnight.	Maxima of the morning.	Minima afternoon.	Maxima of the evening.	Mean extent of the oscillations of the barometer (in hundredths of millim.)	PLACES OF OBSERVATION.
TROPIC.	Leopold de Buch.	....	+ 10h	— 4h	+ 11h	1.10	Las Palmas (in the Island Grand Canaria, lat. 28° 8′ N.)
	Coutelle.	— 5h	+ 10h	— 5h	+ 10½h	1.75	Cairo, lat. 30° 3′.
	Marque-Victor.	summer. + 8½h winter. + 10h		— 5½h — 2½h	+ 11h	1.20	Toulouse, lat. 43° 34′. (Mean of five years.)
	Billiet.	summer. + 7½h winter. + 10h		— 3h — 2h	....	1.00	Chambery, lat. 45° 34′ (height 137 t.)
	Ramond.	summer. + 8h winter. + 9h		— 4h — 3h	+ 10h + 9h	0.94	Clermont-Ferrand, lat. 45° 46′ (height 210 t.)
	Herrensch-neider.	— 5h	+ 8½h	— 3½h	+ 9½h.	0.80	Strasbourg, lat. 48° 34′. (Mean of six years.)
	Arago.	....	+ 9h	— 3h	....	0.72	Paris, lat. 48° 50′. (Nine years of the most precise observations.)
	Nell de Breautté.	....	+ 9h	— 3h	....	0.36	La Chapelle, near Dieppe (lat. 49° 55′.)
	Sommer & Bessel.	....	+ 8½h	— 2⅓h	+ 10h	0.20	Kœnigsberg, lat. 54° 42′. (Eight years.)

Temperate Zone.

MEAN HEIGHT OF THE BAROMETER IN THE TROPICS, AT THE LEVEL OF THE SEA.

Among the numerical elements of which physical geography has long required a precise determination, the mean height of the barometer at the level of the sea in the different zones, is one of the most important. This determination comprehends two questions entirely distinct: 1st. What is the mean absolute height of the barometer on the coasts of Europe, and of equatorial America? 2d. Is that height the same, or does it differ in the temperate and torrid zones? These problems have not hitherto been solved. The determination of the absolute height supposes the exact estimation of the effect of *capillarity*, that is, of the depression of the mercury in the tubes of the barometric basin. M. Arago has been occupied by these very delicate researches, in comparing the barometers of the construction of Fortin, with barometers with syphons. He will soon publish the results of this labor, which will be the more interesting from being linked with the question respecting the invariability of the mean weight of the atmosphere in a long lapse of ages. I shall here only treat of the difference of the mean barometric heights in the parallel of 49°, and in the equatorial regions. This research had

particularly fixed my attention at the period when I quitted Europe. I had carefully compared two of my barometers with that from which M. Bouvard published the meteorological variations made at the observatory of Paris. I thought I should find at Cumana * on the sea shore, the mean height of 337.8^{li}, or 762.02^{mm}, at 25° of the centigrade thermometer, which gives at the temperature of zero, 758.59^{mm}. As at this period (1799) the mean height at the level of the sea in Europe †, was supposed, ac-

* M. Caldas, whom sanguinary political re-actions snatched from the sciences at an age when he could still have rendered them much service, thinks that the difference of the mean height between my observation and that of Shuckburg, arises from the little accordance to be found between a column of mercury boiled, or not boiled in the tubes. (*Semanario*, Tom. i, p. 52.) This cause could not influence my observations at Cumana and La Guayra. I had brought from Europe to Caraccas two barometers, of which the mercury had been boiled in the tubes with the greatest care, by very able artists.

† M. Oriani finds, for Milan, the mean height on the coast of the Adriatic (at 13.5° cent. of temperature) 338.23^{li}, which gives 761.73^{mm} at the temperature of zero. The mean barometric height at the Havannah, according to M. Ferrer, is 25.7° cent. 338.55^{li}, or 763.71^{mm}, or at 0° temp. 760.18. This result is identical with that of M. Boussingault; but we are ignorant of the elevation of M. Ferrer's barometer above the level of the ocean, and the precautions employed at Milan and the Havannah to know the capillarity of the tubes. See *Dei combustibili, Memoria del Conti Bevelacque-Lanzisc,*

cording to Shuckburg, to be 761.18^{mm} (at the temperature of zero), I naturally concluded from that comparison, that the *barometric mean at the level of the sea in the torrid zone, was a little less than in the temperate* *. Uncertain with respect to the capillarity of the barometer I had employed, I estimated that difference at two millimeters in my *View of the Equinoxial Regions*, and which I attributed to the ascending movement of the tropical atmosphere, which bears the layer of air strongly heated, towards the polar regions. Having made, with my instruments, long journies by land from

p. 107. *Schumacher Astr. Nachr. Beil.*, Tom. ii, No. 65; *Hertha*, n. 3, p. 246. On the almost constant depression which the barometer undergoes near Cape Horn, where the western winds blow impetuously, see *Krusenstern, Rec. de Mém. hydr.*, Tom. i, p. 29; *Léopold de Buch; in Gilbert, Ann der Physik.*, Tom. xxv, p. 230; Id. *Barometrische Windrose*, p. 4.

* *See my Essay on the Geography of Plants*, p. 90. In the first half of the 18th century, Richer, Bouguer, La Condamine, Ulloa, and Don Jorge Juan, believed that the barometer at the level of the equinoxial seas, was 27^{in} 11.5^{li}; 28^{in} 0^{li}, or 28^{in} 1^{li}. The instruments used by those travellers had no doubt the air but very imperfectly expelled, for no correction being employed for the temperature, the barometric heights must have been found too great. If the mean barometric heights at the level of the seas of Europe, have been recently a little exaggerated, it is no doubt on account of the uncertainty that envelops the effect of capillarity.

Paris to Marseilles, Murviedro, Madrid, and Corogne, before I embarked for Cumana, I could have but little confidence in my determination. Fortunately, I can now substitute another far more precise. MM. Boussingault and Rivero, before they embarked for La Guayra, compared, conjointly with M. Arago, two excellent barometers of Fortin, with that of the observatory of Paris. The two barometers have preserved the same difference which they had in Europe. M. Boussingault found, at the level of the ocean at La Guayra, the mean of the *maxima* and *minima* observed during twelve days, to be 760.17^{mm} (at the temperature of zero). M. Arago, from nine years of observations at Paris, estimates the mean barometric height (reducing it to the temperature of zero, and the level of the Ocean *) at 760.85^{mm}. The difference of the two mean heights, determined as it were by the same instrument, rises consequently to 0.68^{mm}. We must not forget that in the torrid zone, accidental causes have also an influence on the mean height. I have tried to estimate carefully the probable limits of those changes; and it results from the ana-

* Mean bar. height at Paris, (Royal Observatory), 755.43^{mm}. Difference between the Observatory and the port of Havre, according to a year of correspondent observations made with compared instruments: 5.42^{mm}.

logy of well-observed facts, that even at La Guayra, in another season, the barometric mean, deduced from the *maxima* of 9^h, and the *minima* of $3\frac{1}{2}^h$, might have been found a millimeter more or less. In order to leave no doubt on the question here agitated, we should be able to compare the mean of nine years at Paris, with the mean of one year on the coast of Venezuela. But hitherto we possess one whole year of horary observations for one place only in the tropical zone, between 0° and 15° of latitude; that place is the table-land of Bogota, raised more than 2600 meters above the level of the equinoxial sea.

MEAN TEMPERATURE OF CUMANA. HYGROMETRIC AND CYANOMETRIC STATE OF THE AIR.

During a stay of six months and a half at the town of Cumana (lat. 10° 27′ 52″) I occupied myself simultaneously by researches, 1st, on the mean temperature of the place *, the increase of the heat at different hours of the day, the temperature of the sea during the flux and reflux †, the intensity of the heat of the

* *See Per. Nar.* Vol. iii, p. 386, 458, 568, and 569.

† *L. c.*, Vol. ii, p. 142, 184; Vol. iii, p. 545.

sun measured at different hours by the thermometers placed in the shade, and in the sun; 2d. on the horary variations* of the barometer; 3d. on the hygrometric †, electric, and cyanometric state ‡ of the atmosphere; 4th. on evaporation; 5th. on the quantity of rain that falls in different months; 6th. on the declination and inclination of the loaded needle §, and on the intensity of the magnetic force; 7th. on the mirage, and the influence which the rising and setting of the sun exerts on the inflexion of the trajectories ||. The preceding volumes contain a great number of the results which I obtained; I shall here treat specially of the distribution of heat in the different months of the year, and of the hygrometric, cyanometric, and electric state of the air of Cumana. The experiments I made on the evaporation and intensity of the heat of the solar rays, will be developed later, and will serve as a term of comparison in the statement of the meteorological phenomena observed on the back of the Cordilleras of Quito and Mexico. I made observations at Cumana, with the thermometer, the whalebone

* *L. c.* Vol. vi, p. (631-770).

† Vol. ii, p. 91; Vol. iii, p. 54; Vol. iv, p. 145.

‡ *L. c.* Vol. ii, p. 95, 109; Vol. iii, p. 456.

§ Vol. iii, p. 322—325.

|| Vol. iii, p. 542—554.

hygrometer of Deluc, and the cyanometer of Saussure, during the months of July, August, October, and November 1799, and also during the month of August, 1800; not every day, but often, in order to seize the progressive increase better, ten or twelve times in the same day. During my journey to Caraccas, and the Oroonoko, I begged a very intelligent person, zealous in such researches, M. Faustin Rubio, to mark the indications of a thermometer of Dollond on a register, (and which was concordant with my thermometer to nearly 0.2° cent.) three or four times a day, to 7^h or 8^h in the morning, 2^h and 4^h in the afternoon, and 11^h at night. This thermometer was placed in the shade, in an airy spot, far from the reflexion of the soil, at the Faubourg of the Guayqueries Indians. Cumana being regarded as one of the hottest, dryest, and healthiest places of the low regions of equinoxial America, it is important to make known these partial observations. I take them by chance, out of 1600 I possess; they will serve, above all, to certify that the climate of the tropics is much more characterized by the *duration of the heat*, than by its intensity, that is, by the *maxima* of temperature which the thermometer attains on certain days. I never saw that instrument at Cumana, below 20.8°, nor above 32.8° cent.; and I found on the registers of M. Orta, whose thermometers were

compared by mine, with those of the observatory at Paris, that at Vera Cruz, the *maximum* of heat in thirteen years, had only three times attained 32° cent., and once 35.7°; while we have seen the centesimal thermometer at Paris*, at 38.4°.

* *See* Arago, on the extreme temperatures observed at Paris, in the *Annuaire du Bureau des Long.*, for 1825, p. 164.

I. OBSERVATIONS OF M. DE HUMBOLDT.

July.	*Th. R.*	*Hygr. Del.*
18		
8h m.	18.9°	54° blue.
2	18.4	53 storm.
7 e.	18.7	- - blue.
11 n.	19.0	55
19		
6½ m.	18.7	53 blue.
9	20	50
1	22	- -
2	22.4	49 storm.
6 e.	20.2	00 blue.
24		
7 m.	19.8	60 blue.
noon.	23	50
3	23.2	49.5 blue.
4½	22.5	50
11 n.	18.1	56 blue.
Aug.		
17		
5½	17	58 blue.
9	21	- -
10½	22	- -
2	23	45
4¾	20	48 storm.
6	18	65 rain.
11	18	60 blue.
18		
3 e.	22.5	00 storm.
5	21	49
9 n.	19	55
10	18.5	57 clouds.
10½	18	59 blue.
mid.	18	62 blue.
26		
noon.	23	53 blue.
3 e.	23.3	48
5	22.5	47.6
7	20.3	51 blue.
11 n.	18.1	53 wind.
mid.	18.0	00 blue.
27		
8½	19.2	57.5 blue.
9	19.5	57
11½	22.5	49 clouds.
noon.	24.0	48
2 e.	23.5	47 storm.
4	20	50.5

Aug.	*Th. R.*	*Hygr. Del.*
6h	18.7°	54°
7	18.5	55 cloudy.
8	18	59 blue.
mid.	17.5	60.5
29		
11 m.	22.5	52 blue.
noon.	24.5	- -
4 e.	23	51
4½	24	51 blue.
7	19.5	61 overcast.
mid.		67 blue.
30		
7½ n.	21.1	51 blue.
noon.	25.0	49
2	26	47 storm.
8 e.	19.2	56 blue.
11	19	60
mid.	18.5	60.2 blue.
31		
8½	20.3	54 blue.
11	23	49
noon.	23.6	48
2	23.4	47.7 blue.
4	22.5	48
11 n.	19	50
mid.	18.3	52
	18	56 blue.
Oct.		
22		
8	20.4	00 blue.
10	21.5	- -
noon.	21.6	- -
1	23.8	- -
2	23.9	- -
2½	23	00 blue.
3	22	- -
5	21.5	- -
6	20.9	- -
8½	19.2	00 mists.
10	19.2	- -
mid.	19.1	00 mists.
23		
8½	20.5	53.5
10	22	52.5
1	24.3	49.5
3 e.	24	49.5
4½	22	50.3
6	20.5	53
11 n.	20	56.1

(*Continuation.*)

Oct.	*Th. R.*	*Hygr.*	*Del.*
24			
10h	22°	51.8°	
11	23	51	
noon.	23.5	50.5	
1	23.2	50	
5½	19.5	52.5	
6	19.2	54	
10	18.8	55.5	
mid.	18.6	56.5	
25			
9	21	52.5	
noon.	22.4	50.5	
2	23	49.8	
5	19.3	52.2	
10 n.	19	62.3	
26			
9	20.5	53.5	
2 e.	23.2	50	
5	20.2	52	
9	20	54	
mid.	18.2	56.5	
27			
8	20.2	52.6	
11	21.5	51	
noon	23.2	50	
11 n.	19.5	52.5	
Nov.			
3			
9	21	54	
noon.	22	51	
2	23	49	
6	20.5	58	
4			
9	22.4	49	
2 e.	23.2	48	
5	22.5	54	
7	21	60	
11 n.	19	66	
5			
10	22	54	
noon.	22.5	50	

Nov.	*Th. R.*	*Hygr.*	*Del.*
5			
3h	23o	49.4°	
4	20.2	50.2	
5½	20.1	51.5	
10	17.7	64	

The thermometer, (division of Reaumur) is reduced to that of the cellars of the observatory at Paris, which, according to researches made after my return to Europe, was found 0.37° cent. too high. The hygrometer was of whalebone. These indications are not corrected by the temperature. On the night of the 17th of August, when the thermometer sank rapidly to 18°, at the same instant (by the cooling of the upper layers of the air) a fine halo was formed around the moon. On the 25th of August, during a furious north-east wind, the thermometer sank at 9h in the evening to 17.5° R. This was the beginning of the small rains which form what the people of Cumana call the winter season.

Days considered as excessively hot at Cumana, 1799, and 1800,

27 Aug. at noon 24.0° Reaumur.
29 ———— 24.5
30 ———— 26.0
10 Oct. the whole day - - - - - - 24.2
the whole night 23.0
26 March at 2h - 25.7
14 May at 4h - - 26.0

When the thermometer at Cumana, has been at 23°-25° (hygr. 48° Deluc), during three days, we experience a feeling of cold when the thermometer descends after a storm of rain, to 18°—19° R. (hygrometer 62° Deluc). *See* above, Vol. ii. p. 252.

Sept.	*Th. R.*	*Hygr.*	
1			
8h m.	20.8°	82°	Saussure.
10 n.	20.7	86	
2			
9 m.	21.3	78	
3 e.	22.2	82	
mid.	20.7	84	
3			
10 m.	22.5	76	
1 aftn.	20.9	83	
4			
7 m.	20.7	82	
3 e.	22.5	87	
11 n.	22	78	
5			
1 e.	22.8	37	Deluc.
3	23.0	36	
11 n.	22.5	37	
6			
3 e.	22.5	33.5	
11 n.	20.7	36	
7			
5 m.	19	43	
3 e.	23.5	35	
1 n.	19.5	49	
8			
9 m.	23.3	33	
3 e.	26.0	31	
1 n.	20.2	37	
9			
9 m.	23.5	27	blue.
10 n.	22.5	45	rain.
mid.	18.3	50	blue.
10			
1 e.	24.0	29	
3	19.7	37	rain.
mid.	18.8	50	
3 m.	18.3	50	

Sept.	*Th. R.*	*Hygr.*	
11			
9h m.	20.2°	41°	
noon.	22.9	30	
mid.	19.3	40	
12			
8 m.	20	37	
noon.	24	31	
11 n.	21	38	
13			
5½ m.	19	41	
noon.	23.7	32	
1 n.	17.5	59	
14			
7	18	47	
noon.	23	32	
11 n.	18.7	49	
15			
5½	18.5	47	
7	21	38	
8	21.2	33	
10	23	32	
noon.	23.3	32	blue.
3	19	70	rain.
6	19.5	55	
11 n.	18	53	
16			
8 m.	17.5	43	
3 e.	22.0	33	
11 n.	19	48	

From 1st to 4th September, hygr. of Saussure, from 5th to 16th September, hygr. of Deluc.

OBSERVATIONS OF THE CYANOMETER.

Days.	*Cyanom.*	*Th. R.*	*Hygr.*	
18 *Aug.*				
noon.	21°	22.4°	38°	Deluc.
29 noon.	22	24.5		
30 noon.	19	24.8		
31 noon.	16	21	38.9	
11 *Sept.*				
7h m.	11.3	18	42	
7¾	14	20.3	41.5	
8	13	20.2	41	
9	14	22	36	
10	14	23	31.5	
11	17.7	22.9	30	
3 e.	18	23.6	30	
14				
7 m.	13.7	18	47	
9	17	21.2	40	
10	18	21.7	35.4	
noon.	23	23.8	30	
16				
8 m.	14.5	17.5	43	
9	18.5	20.8	41	
11	19·5	22	34	
18				
6¾ m.	15	18.4	43	
7	16.3	19.2	41.7	
7¾	17.0	20.3	41	
8	17.8	21.3	40	
9	17	21.4	38.2	
9½	18	21.7	36	
11	22	23.5	32	
noon.	22	23.8	29	
1	23	24.5	29	
3	17	24.3	32	

Days.	*Cyanom.*	*Th. R.*	*Hygr.*
19 *Aug.*			
6½	15°	16.7°	40.7°
7	16.8	17.5	39
7½	18	19.4	38.5
8	20	19.5	37.4
8½	20	21.2	36
9	20.4	21.7	35
9¾	19	22.6	33
11	18	23.5	30.2
noon.	18	23	29

The observations of the cyanometer were extremely fatiguing, on account of the intensity of the light in those regions. Calm and serene days were chosen. The observation always at the zenith, or near the zenith. When the wind rises, the tint of the sky becomes a little paler, without any change in the hygr., or the vesicular vapors becoming visible. The colour of the sky is generally at Cumana, from 22° to 24° at noon, by the cyanometer of Saussure, while at Paris (by 20° R. of temperature) it is most frequently 16°. Sometimes (the 31st of August, and the 19th of September) the sky was singularly pale, without there being the least breath of wind. *See* above, vol. ii. p. 95, 109.

Often, in a very strong wind, we enjoyed an extraordinary coolness, although the thermometer had only lowered 1.5° R., and the hygrometer of Deluc had moved but 3° towards the point of extreme humidity. The stars do not scintillate at Cumana, above 25° of elevation; yet on the 24th and 26th of October, the scintillation became very sensible to the zenith, when the thermometer had descended rapidly to 18.5° R. The scintillation seems to augment at Cumana, less by the humidity, than by a sudden cooling, and by ascending and descending currents that mix layers of air of very different densities. The hygrometer indicates so little scintillation, that I have seen it pass from 50° to 59°, even to 62° (division of Deluc), and yet the stars, far from scintillating, preserved, below 25°, their tranquil and planetary light. These phenomena confirm the ingenious explication given by M. Arago, of scintillation. (Vol. iii, p. 313—315, 538; Vol. iv, 94, 467). No hail ever falls at Cumana, although the electric explosions are frequent two hours after the *maximum* of heat. When the thermometer was 24° R. in the air, the coolest water which the inhabitants prepared by evaporation (by exposing it to the currents of air, in pots that transude a little), was 21° R. Mr. Chisholm says "I never could refresh water within the tropics, in vases, below 72° Fahr." (17.7° R.).

Some delicate experiments which I tried, to verify the point of extreme humidity of my whalebone hygrometer, at the moment of my departure from Cumana for Caraccas, led me to suspect that towards the end of October, that instrument indicated 1.8° of too great humidity. The 50th degree of my hygrometer of Deluc, was perhaps equal only to 84.7° of the hair hygrometer, while the 50° of an hygrometer of Deluc, well rectified in those extreme points, make 85.5° of the hair hygrometer of Saussure. The 5th of September, at 3^h in the afternoon (th. 23° R.; hygr. 36° Del.), I saw *large drops of rain* fall from a sky quite blue, and without any traces of clouds. The same day, between noon and 3^h, the thermometer rose, in the streets of Cumana, in the shade, but exposed to the reflection of the edifices, five feet above the soil, to 29° R. (36.2° cent.). *The inhabitants of Cumana are exposed to that heat during the greater part of the year, in the open air, in the streets, and great squares, on a white and pow dery soil.* When the mean temperature of the day (from sun-rise to sun-set, without reckoning the night), is 22°-24° R., great coolness is enjoyed between 17°-19° R. (21.8°-23.7° cent.). In the driest time, during the night, (at 19° R.), the hygrometer of Deluc often keeps up at 30° (65.3° Saussure). Sunrise makes the hygrometer move to humidity, but very slowly. The

17th September, the hygrometer of Deluc, at 4^h in the morning, 44.7° (th. 17.9° R.). During twilight, which lasts but some minutes, hygr. 45.5° (th. 17.5°). The evaporation caused by the first unreflected rays of the sun produces cold. At 6^h, a little wind is felt, as in Europe; hygr. 44.5° (th. 17.8°); at $6\frac{1}{2}^h$, hygr. 38°. The 19th September, hygr. at midnight, 35° (th. 19.4°); at 4^h in the morning, hygr. 39° (th. 19°); at 6^h in the morning, hygr. 41° (th. 22° R.). In examining the whole of my hygrometric observations at Cumana, I find 22° R. (27.5° cent.) of temperature.

Mean of the day, July	47.6°	of night 56.2°	of 24^h 51.9°
Aug.	45.4	58.0	51.7
Oct.	46.7	55.7	51.4
Mean of 3 months	46.6	56.7	51.7 Deluc.
or	83.5	89.1	86.3 Sauss.

At Geneva, the mean of 1796-1802 also yields 82.3° of the hygrometer of Saussure, but by 9.6° cent. of temperature. When the estimates of the atmospheric humidity in degrees of the hygrometer of Saussure, draw near each other (between 83°-89°), the arithmetical mean differs very little from the real hygrometrical mean. The error would become serious between 70° and 90°, as we may be convinced in examining the table of the tension of the vapors, founded

on the fine experiments of M. Gay-Lussac. During several singularly dry days in the month of September, I saw the hair hygrometer descend at Cumana to 64° (29.5° of the whalebone hygrometer), at a temperature of 28.7° cent.

Rains and Storms.

The rainy season, which in other parts of the tropics yields 100 to 115 inches of water (Vol. vi, p. 276) per year, produces scarcely seven to eight inches at Cumana. I collected in September and October (rainy season):

August 31	3.2li
September 8	2.0
9	5.4
12	6.1
15	2.1
16	6.7
18	3.8
30	0.7
October 2	8.8
4	13.7
6	3.3
22	10.5
24	0.9
28	4.2
30	0.9
	72.3 lines, or 0.163m.

The most violent showers produced partially 14 lines of water, which falls in drops of an enormous size; and this characterizes the small rains of the tropics, that they fall in drops which remain at a great distance from each other. There have been years (1798 and 1799), when during nine months, from December to September, the rains did not yield two inches of water. In the New Continent, the drought of Cumana, Punta Araya, and the island of Marguerita, can be compared only with the province of Ciara in Brazil, where sometimes (1792-1796) it does not rain during several years. (*Corogr. Bras.* ii, p. 221.) The vegetation, notwithstanding the drought, is fresh at Cumana, for instance, near the *Chara de Capuchinos*. The dew is almost null; the little water that falls at Cumana descends in showers with extraordinary rapidity; these showers last in general but from fifteen to twenty minutes. I saw $4\frac{1}{2}$ lines at the *maximum*, fall in six minutes. All my measurements were made in cylindric vases, and in such a manner that the evaporation could not lead to error. During the great storm of September 16th, 1802, at Cumana, I placed two cylindric ombrometers, at heights which differed only twenty-two feet perpendicularly. It rained with violence from $3^h\,25'$ to $4^h\,5'$; I found in the most elevated ombrometer, $6\frac{7}{10}$ lines of water, and in the

lowest, 7½. Doctor Heberden has seen differences as far as fifteen feet in height. I remarked no difference on the 28th September, and the 2d of October, between the two stations of the ombrometer. The rains of these countries are electric, and are preceded by very sensible signs of electricity on the electrometer of Volta, armed with a burning wick. What struck me above all at Cumana, was, that a few minutes before the rain fell, the hair hygrometer continued not only to indicate 67° to 68°, which is a considerable drought for that country, but that (without any change of temperature) it *retrogrades* one to two degrees towards drought, in proportion as the sky becomes obscure, and takes that intensity of dark blue which precedes the electric explosions. At Cumana, the words *thunder, winter*, and *rain (trueno, invierno, aguasero,)* are synonimous. The thermometer, while it rains, goes down from 24° R., at the utmost to 19°. The sky, in darkening, remains uniformly blue, displays no vapors divided into groupes, and acquires an intensity of colour that goes to 47° of the cyanometer. The cocoa-trees, and all the plants with glossy leaves, are detached in *light* on the azure vault, and appear suddenly to draw nearer to the observer: a perfect calm reigns in the air. The atmospheric electricity, which I found generally null at Cumana, from 7^{h} in the morning

till 2^h in the afternoon, in trying it with the electrometer of Volta, on a terrace thirty feet high, and entirely open, becomes suddenly so strong that the divergence of the balls rises to eight lines, and it is soon no longer necessary to arm the instrument with a wick. The electricity often passes from positive to negative, without thunder being heard. In a great number of storms the electric charge of the air appeated to me to be negative twenty minutes before the strongest explosions, although I made my experiments far from any trees, in the middle of the *Salado*, in a vast plain. The rain that falls during the storm, is sometimes of the temperature of 17.8° ; and I then found it a degree colder than the air, at the moment of the shower. Having made many experiments in the open country, in temperate climates, at Salzbourg, Bayreuth, Vienna, Marseilles, and Corogne, I can affirm that the electric charge, which becomes sensible within the tropics, during the storm, in the low regions of the air, is of surprising intensity. After three quarters of an hour of storm, lightening, and rain, I saw in the electrometer of Volta, without the conductor being armed with a wick, a separation of the balls of ten lines. Often, at the instant of the thunder, the electricity does not change from + into —, or from — into + ; sometimes these passages are not accompanied with any

explosion; at other times the electricity which was positive 14 lines, becomes suddenly zero at the instant of the thunder, remains null during four or five minutes, and again becomes positive. The great electric clouds appeared to me in general to be much more elevated in the torrid zone than in Europe, and the people believe that the thunder much more rarely reaches the earth.

II. OBSERVATIONS OF DON FAUSTINO RUBIO.

I shall give only the partial observations in degrees of the thermometer of Fahrenheit, for the two months of January and May, of which the mean temperature differs most.

JANUARY, 1800.

DAYS.	THERMOMETER at 7h in the morning.	THERMOMETER at 2h in the afternoon.	THERMOMETER at 11h at night.
3	78°	82°	81°
4	78	85	
5	79	83	
6	77	84	80
7	76	82	80
8	76	82	80
9	80	85	81
10	80	84	80
11	78	83	80
12	80	83	80
13	79	83	78
14	74	82	79
15	76	82	80
16	77	82	80
17	76	83	80
18	76	85	81
19	78	84	80
20	78	84	80
21	79	85	80
22	75	83	80
23	76	83	80
24	75	83	80
25	78	85	80
26	79	85	80
27	78	84	80
28	77	83	81
29	76	84	81
30	78	85	80
31	76	82	79

(*Continuation*).

OBSERVATIONS OF DON FAUSTINO RUBIO.

MAY, 1800.

DAYS.	THERMOMETER at 7^h in the morning.	THERMOMETER at 2^h in the afternoon.	THERMOMETER at 11^h at night.
1	81°	89°	84°
2	82	87	84
3	82	89	84
4	81	88	84
5	82	88	84
6	82	88	85
7	82	89	85
8	82	89	84
9	81	88	83
10	81	87	83
11	82	86	83
12	81	88	
13	82	88	86
14	81	90	86
15	81	89	86
16	81	88	84
17	81	89	84
18	81	88	83
19	82	89	83
20	81	86	81
21	81	88	83
22	80	88	83
23	82	88	83
24	80	88	83
25	81	89	83
26	79	89	82
27	80	88	84
28	82	87	
29	8	88	83
30	82	87	82
31	73	86	83

The uniformity of the temperature at the same hours is very remarkable; in the same two months, according to the very precise observations of MM. Boussingault and Rivero, in the climate of Bogota, called *extremely variable*, the centigrade thermometer varies in the different days, but 1° or 1.5°. It results from the whole of these observations, of which I am in possession, that we may admit for

Cumana (5 t.)

Mean temperature of the year.....	27.7° cent.
The hottest month	29.1
The coldest month	26.2

S. Fe de Bogota (1366 t.)

Mean temperature of the year.....	14.6° cent.
The hottest month	16.3
The coldest month	14.4

The observations from the 19th of November to the 26th of August only, give for Cumana, employing only the *minimum* of 7^h in the morning, and the *maximum* of 2^h in the afternoon:

MEAN OF THE MONTHS.		EXTREME TEMPERATURE.	
		maxima.	*minima.*
November	22.76° R.	24.8° R.	23.1° R.
December	21.70	24.0	21.7
January	21.49	23.5	22.2
February	21.56	24.4	22.2
March	21.20	25.3	23.1
April	23.04	25.7	23.5
May.....	23.35	26.2	24.2
June.....	22.71	24.8	21.3
July	21.79	24.4	21.3
August.....	22.00	24 8	22.2
Mean...	22.16 R.	24.8 R.	22.5 R.
or	27.60 cent.	30.9 cent.	28.7 cent.

Perhaps the general mean of Cumana is some decimals more, because the temperature of the months of September and October a little exceeds that of the month of August. The mean of the extreme *(maxima)* of heat, surpasses only 3.3° cent. the mean of the whole year. In comparing the mean temperature of three towns of the republic of Columbia in which a great number of meteorological observations have been made, we find, Cumana (lat. 10° 27′; height 5 toises), 27.7° cent.; Caraccas (lat. 10° 31′; height, 480 t.) 21.5°; Santa Fe de Bogota (lat. 4° 35′; height, 1366 t.) 14.6°. At the extremity of the torrid zone, at the Havannah (lat. 23° 10′) the mean temperature of the air differs very little (2.1° cent.) from the mean

temperature of Cumana; but the difference of the coldest month in these two places is 5°. (*See* above, Vol. iii, p. 386 and 463.)

ADDITIONAL NOTE ON THE HEIGHT OF THE LAKE OF NICARAGUA ABOVE THE LEVEL OF THE SEA.

In discussing above, the obstacles which may prevent the possibility, and even the utility of an *oceanic canal*, (similar to the Caledonian canal, and the canal recently completed in North Holland,) between the eastern and western coasts of America, I spoke of the great height of the basin of Nicaragua. I regretted at the same time, that since my return to Europe, no precise measurement has been made in the isthmus of Huasacualco, Nicaragua, Panama, and the Atrato. (Vol. vi, p. 241, 253, 269, 281.) It is only at the moment when these sheets are about to appear, that I have had a communication of a very important document, which proves that, " by order of the court of Madrid, addressed to the captain-general of Guatimala, Don Matis de Galvez, the engineer Don Manuel Galisteo executed a survey, in 1781, by means of a water level, from the gulph of Papagayo, on the coast of the South-Sea, as far as the Laguna de Nicaragua; and that, by three hundred and thirty-six stations of ascent, and three hundred and thirty-nine stations of des-

cent, (*ascensos:* 604^{ft} 8^{in} 8^{li}, Castille measure; *descensos:* 470^{ft} 1^{in} 7^{li}), the surface of the lake of Nicaragua was found to be elevated 134^{ft}. 7^{in} 1^{li} above the South Sea. But the lake is 88^{ft} 6^{in} deep; so that its bottom is still 46 Castillian feet above the level of the South Sea. The Rio Panaloya, by which the lake of Leon communicates with the lake of Nicaragua, presents a bar *(salto)* of from 25 to 30 *varas*." (According to M. Ciscar, 1 *vara castellana* = 3 feet of Burgos = 0.429^{t}.) This document does not mark the direction and the extreme point of the line of levelling, its object being only the determination of the height of the lake; it does not appear to be hitherto proved that the ridge of partition has every where the great elevation of 85 toises; and that between Realejo and Leon, the gulph of Papagayo, or that of Nicoya, and the lake of Nicaragua, there exists no depression of soil, no transversal valley fit to receive the waters of a canal of great navigation. In the survey made by the commandant of the castle of Omoa, Don Ignaicio Maestre, and the engineers Don Joaquim Ysasy, and Don Jose Maria Alejandro, it was affirmed that the lake of Nicaragua has no natural communication with the South Sea; it was observed at the same time, that the mountainous land *(aspero y montuoso)*, between the Villa of Grenada, and the port of Culebra, renders all communication

by canals extremely difficult, if not impossible on that point. According to the testimony of Captain Cochrane, (*Journal of a Residence and Travels in Columbia during the years* 1822 *and* 1824, Vol. ii, p. 448), three ranges of hills separate the bay of Cupica, and the banks of the Naipi. (*See* above, Vol. vi, p. 250.)

BOOK X.

CHAPTER XXVII.

Passage from the Coast of Venezuela to the Havannah.—General View of the Population of the West Indies, compared with the Population of the New Continent, with respect to the Diversity of Races, Personal Liberty, Language, and Worship.

SINCE the improvement of the art of navigation, and the increasing activity of commercial nations, have drawn the coast of the two continents nearer to each other; since the Havannah, Rio Janeiro, and Senegal scarcely appear to us more distant than Cadiz, Smyrna, and the ports of the Baltic, we hesitate in calling the attention of the reader to a passage from the coast of Caraccas to the island of Cuba. The Caribbean Sea is like the basin of the Me-

diterranean; and if I here note some observations drawn from my nautical journal, it is that I may not lose the thread of my narrative, and to recall some facts that are connected with meteorology and physical geography in general. In order to know well the modifications of the atmosphere, they must be studied on the declivity of mountains, and in the immensity of seas; there is no passage however short, no voyage even to the Canaries, or the Madeira islands, which may not give rise to new views in the minds of naturalists long accustomed to interrogate nature in the retirement of their study.

We sailed from the road of Nueva Barcelona on the 24th of November, at nine in the evening; and doubled the small rocky island of Borachita; there is a very deep passage between this island and the Gran Boracha. The night had that coolness which characterizes the nights of the tropics, and of which the agreeable effect can only be conceived by comparing the nocturnal temperature from 23° to 24° cent., with the mean temperature of the day, which in those latitudes is generally, even on the coast, from 28° to 29°. The next day, soon after the observation of noon, we reached the meridian of the island of Tortuga: destitute of vegetation, similar to the small isles of Cooke and Cabagua, it is remarkable for its

small elevation above the level of the waters. Some doubts having been recently thrown on the astronomical position of Tortuga, I shall here state that, by the time-keeper of Louis Berthoud *, the centre of the island was 0° 49′ 40″, west of Nueva Barcelona. I believe that longitude to be a little too westerly.

November 26th.—A dead calm, so much the more unexpected, that in general the breeze from the eastward blows fresh on this coast from the beginning of November, while from the month of May till October, the N.W. and S. winds are felt occasionally. At the period of the N.W. wind, a current † is observed running from west to east, which sometimes favors during two or three weeks, the direct navigation from Carthagena to the island of Trinidad. The south-wind is regarded as very unhealthy on all the coast of the continent, bringing (as the people say), the putrid emanations of the forests of the Oroonoko. Towards 9ʰ in the morning a fine halo was formed around the sun, at the moment when the temperature in the low regions fell suddenly three degrees and a half. Was this lowering the effect of a descending current? The zone that formed the halo, and which had one degree of breadth, was

* *Obs. Astr., Intr.*, p. 42; and Vol. ii, p. 2.

† *Per. Nar.*, Vol. iii, p. 378.

not white, but displayed the most beautiful colours of the rainbow, while the interior of the halo, and the whole vault of the sky was azure, without any trace of visible vapors.

We began to lose sight of the island of Marguerita, and I endeavoured to verify the height of the rocky groupe of Macanao. It appeared under an angle of 0° 16′ 35″; which, in a distance estimated at sixty miles, would give the groupe of mica-slate of Macanao the elevation of about 660 toises, a result * which, in a zone where the terrestrial refractions are so constant, leads me to think that the island was less distant than we supposed. The dome of the Silla of Caraccas, remaining 62° S.W. long drew our attention. We contemplate with pleasure the summit of a lofty mountain which we have climbed with danger, and which sinks gradually below the horizon. When the coast is not loaded with vapours, the Silla must be visible at sea, without counting the effects of refraction, at thirty-three leagues distance †. During that day, and the three following days, the sea was covered with a bluish skin, which, examined by a compound microscope, appeared formed of an innumerable quantity of filaments. We frequently find these filaments in the Gulf-stream,

* Vol. ii, p. 45; Vol. vi, p. 498.

† Vol. iii, p. 506.

and the Channel of Bahama, as well as near the coast of Buenos Ayres. Some naturalists think they are the vestiges of the eggs of mollusca: they appear to me to be rather the fragments of fuci. The phosphorescence of sea-water seems to be augmented, however, by their presence, above all, between the 28° and 30° of north-latitude, which indicates an origin of an animal nature.

November 27th.—We approached slowly the island of Orchila; like all the small islands in the vicinity of the fertile coast of the continent, it has remained uninhabited. I found the latitude of the north cape, 11° 51′ 44″, and the longitude * of the eastern cape, 68° 26′ 5″ (supposing Nueva Barcelona 67° 4′ 48″). Opposite the western cape is a small rock against which the waves beat turbulently. Some angles taken with the sextant, gave, for the length of the island from east to west, 8.4 miles (950 toises); for the breadth scarcely three miles. The island of Orchila, which, on account of its name, I figured to myself as a bare rock covered with lichens, displayed at that period a beautiful verdure. The hills of gneiss were covered with gramina. It appears that the geo-

* *Astr. Obs.*, Vol. ii. p. 3. Nearly the longitude of Purdy's map (1823), and the latitude of the map of the *Dep. de Madrid* (1809).

logical constitution of Orchila resembles, on a small scale, that of Marguerita; it is composed of two groupes of rocks joined by a neck of land; it is an isthmus covered with sand, which, seems to have issued from the floods by the successive lowering of the level of the sea. The rocks, like all those which are perpendicular, and insulated in the middle of the sea, appear much more elevated than they really are, for they scarcely attain from 80 to 90 toises. The *Punta rasa* stretches to the north-west, and is lost like a sandbank below the waters. It is dangerous for navigators, like the *Mogote*, which, at the distance of two miles from the western cape, is surrounded by breakers. In examining these rocks very near, we saw the strata of gneiss inclined towards the north-west, and crossed by thick layers of quartz. These layers have no doubt given place by their destruction, to the sands of the surrounding beach. Some clumps of trees shade the vallies; the summits of the hills are crowned with palm trees with fan-leaves. It is probably the *Palmo de sombrero* * of the Llanos (corypha tectorum). The rains are not abundant in these countries; it is probable, however, that some springs might be found on the island of Orchila, if they were sought for with the same

* *See our Nova Genera Plant. Equin.*, Tom. i, p. 299.

care as in the rocks of mica-slate of Punta Araya. When we recollect how many bare and rocky islands are inhabited and cultivated with care between the 17° and 26° of latitude in the archipelago of the Little Antilles and the Bahama islands, we are surprised to find the islands near the coast of Cumana, Barcelona, and Caraccas, desert. They would long have ceased to be so had they belonged to any other government than that which is in possession of the continent. Nothing can engage men to circumscribe their industry within the narrow limits of an island, when a neighbouring continent offers them greater advantages.

We perceived at sunset, the two points of the *Roca de afuera*, rising like towers in the midst of the Ocean. A survey taken with the compass, placed the most easterly of the *Roques* at 0° 19′ west of the western cape of Orchila. The clouds remained long accumulated over that island, and shewed its position from afar. The influence of a small track of land in condensing the vapours suspended at an elevation of 800 toises, is a very extraordinary phenomenon, although familiar* to all mariners. From this accumulation of clouds, the position of the

* *Henry Stubb*, in the *Phil. Trans.*, 1667, No. 27, p. 497 and 718. *Courejolles*, in the *Journ. de Phys*, Vol. liv, p. 109.

lowest island can be recognized at a great distance.

November 29th.—We still saw very distinctly at sunrise, the summit of the Silla of Caraccas almost touching the horizon of the sea. We believed we were 39 or 40 leagues distant, which, regarding the height of the mountain as being well determined (1350 toises), its astronomical position, and that of the ship, would indicate rather a strong refraction for that latitude, between 1-6th and 1-7th. At noon every thing denoted a change of weather towards the north; the atmosphere * suddenly cooled to 12.8°, while the sea preserved a temperature of 25.6° at its surface. At the moment of the observation of noon, the oscillations of the horizon, crossed by streaks or black bands of very variable size, produced changes of refraction † from 3′ to 4′. The sea became rough in very calm weather, and every thing announced a stormy passage between the island of Cayman and the cape Saint Antoine. On the 30th of November, the wind veered suddenly to N.N.E., and the surge rose to a considerable height. The sky displayed on the north a darkish blue

* The temperature is estimated by the centesimal thermometer wherever the contrary is not expressly indicated.

† I estimate those changes by the quantity which the height of the sun suddenly augmented after its passage by the meridian.

tint: the rolling of our small vessel was violent, and we perceived amidst the dashing of the waves, two seas crossing each other, one from the N. and the other from N.N.E. Water-spouts were formed at the distance of a mile, and were carried rapidly from N. N. E. to N.N.W. Whenever the water-spout drew near us, we felt the wind grow sensibly cooler. Towards the evening, by the carelessness of our American cook, the deck took fire; it was happily soon extinguished; for in bad weather, accompanied by squalls, and with a cargo of meat, which the fat renders extremely combustible, the fire would have made a rapid progress. In the morning of the 1st of December, the sea sunk slowly, as the breeze became fixed from N.E. I was at this time pretty certain of the uniform movement of my chronometer; but of this the Captain wished to be assured by the survey of some points of the island of Saint Domingo. On the 2d December we descried Cape Beata, in a spot where we had long marked the clouds heaped together. According to the heights of Achernar, which I obtained in the night, we were sixty-four miles distant. The night displayed a very curious optical phenomenon, which I shall not undertake to explain. It was half an hour past midnight; the wind blew feebly from the east; the thermometer rose to 23.2°, the whalebone hy-

grometer was at 57°. I had remained upon the deck to observe the culmination of some great stars. The full-moon was very high; suddenly, on the side of the orb, 45′ before its passage over the meridian, a great arc was formed tinged with all the prismatic colours, but of a gloomy aspect. The arch appeared higher than the moon; this iris-band was near 2° broad, and its summit seemed to rise nearly from 80° to 85° above the horizon of the sea. The sky was singularly pure; there was no appearance of rain; and what struck me most was, that this phenomenon, altogether resembling a lunar rainbow, was not opposite to the moon. The arch remained stationary, or at least appeared to do so, during eight or ten minutes, and at the moment when I tried if it were possible to see it by reflection in the mirror of the sextant, it began to move and descend, crossing successively the Moon and Jupiter, placed at a small distance below the Moon. It was 12h 54′ (real time) when the summit of the arch sank below the horizon. This movement of a coloured arch filled with astonishment the mariners who were upon their watch on the deck; they pretended, as they do on the appearance of every extraordinary meteor, that "it announced wind." M. Arago examined the sketch of this arch in my journal, and thinks that the image of the moon reflected in the waters would not

have given a halo of so great a dimension. The rapidity of the movement is not a small obstacle to the explanation of a phenomenon well worthy of attention.

December 3d.—We had some uneasiness on account of the proximity of a small vessel which was believed to be a pirate, but as it drew near was recognized for the *Balandra del Frayle* (the sloop of the Monk). I could scarcely conceive what so strange a denomination meant. The bark belonged to a Franciscan missionary *(Frayle Observante)*, a rich priest of an Indian village in the savannahs (Llanos) of Barcelona, who had for several years carried on a very lucrative contraband trade with the Danish islands. M. Bonpland, and several passengers, saw in the night at the distance of a quarter of a mile, with the wind, a small flame on the surface of the Ocean; it ran towards the S.W. and lighted up the atmosphere. No shock of earthquake was felt, and there was no change in the direction of the waves. Was it a phosphoric gleam produced by a great heap of mollusca in putrefaction; or did this flame issue from the depth of the sea, as is said to have been sometimes observed in latitudes agitated by volcanoes? The latter supposition appears to me destitute of all probability. The volcanic flame can only issue from the deep when the rocky bottom of the

Ocean is already heaved up, so that the flames and incandescent scoria escape from the swelled and creviced part, without traversing the waters.

December 4th.—At half past ten in the morning we were in the meridian of Cape Bacco *(Pta Abacou)*, which I found at 76° 7′ 50″, or 9° 3′ 2″, west of Nueva Barcelona. In time of peace the vessels that trade in dried meat *(tasajo)* between Cumana and Barcelona, or the Havannah, set out, according to the antient practice of the Spanish mariners, by the channel of Portorico, to take the *old channel*, on the north of the island of Cuba; sometimes also they pass between cape Tiburon and cape Morant, going along the northern coast of Jamaica. But in time of war, these passages become alike dangerous, the ship remaining too long in sight of land. Having attained the parallel of 17°, the fear of pirates made us prefer the direct passage across the bank of Vibora, better known by the name of *Pedró Shoals*. This bank occupies more than 280 square marine leagues, and its configuration strikes the eye of the geologist, on account of its resemblance to that of Jamaica, which is in its neighbourhood. It seems like a heaving up of the bottom which could not attain the surface of the sea, and forms an island almost as large as Portorico. From the 5th of December, the pilots believed

they took successively the measurement at a distance of the island of Ranas *(Morant Kays)*, Cape Portland, and Pedro Kays. They were probably deceived in several of these distances, taken from the top of the mast. I have elsewhere noted these measurements *, not to put them in opposition to the great number which have been made by able English navigators, in these frequented latitudes, but merely to connect, in the same system of observations, the points I determined in the forests of the Oroonoko, and the archipelago of the West Indies. The milky color of the waters warned us that we were on the eastern part of the bank; the centigrade thermometer, which at a distance from the bank had kept up, on the surface of the sea, for several days at 27° and 27.3° (the air being at 21.2°), cooled suddenly to 25.7°. The weather was bad from the 4th to the 6th of December; it rained fast; the thunder rolled at a distance, and the gusts from N.N.E. became more and more violent. We were, for some time of the night in a critical position; we heard before the prow the noise of the breakers over which we had to pass, and we ascertained their direction by the phosphoric gleam reflected by the foam of the sea; the scene resembled the Raudal of Garzita, and

* *Astr. Obs., Introd.*, Vol. i, p. xliii; Vol. ii, p. 7-10.

other rapids which we had seen in the bed of the Oroonoko. The captain accused less the negligence of the pilot, than the imperfection of the charts. We succeeded in turning our course, and in less than a quarter of an hour we were out of danger. The soundings indicated first 9, then 12, then 15 fathoms; we remained near the cape during the rest of the night; the north-wind made the thermometer descend to 19.7° (15.7° Reaum.) The next day I ascertained by chronometric observations, combined with the results of the *corrected* reckonings of the past night, that the breakers nearly at 16° 50′ of latitude, and 80° 43′ 49″ long. The breaker on which the Spanish vessel *el Monarca* had nearly perished in 1798, is in lat. 16° 44′, and long. 80° 23′, consequently more to the east. While we traversed the bank of the Vibora, in the direction from S.S.E. to N.N.W., I repeatedly tried to measure the temperature of the water at the surface of the sea. The cooling was less sensible on the middle of the bank than on its edge, which we attributed to the currents that there mingle waters of different latitudes. On the south of Pedro Kays, the surface of the sea at 25 fathoms deep, was 26.4°; and at 15 fathoms deep, 26.2°. The temperature of the sea on the east of the bank had been 26 8°. These experiments can only yield a precise result in those

latitudes, when made at a time when the wind does not blow from the north, and when the currents are less violent. The north-winds and the currents cool the water by degrees, even where the sea is very deep. On the south of cape Corientes, lat. 20° 43′, I found the sea at its surface 24.6°, and the air 19.8° cent. Some American pilots affirm, that among the Bahama Islands they can often guess, when seated in the cabin, that they are passing over sand-banks; they pretend that the lights are surrounded with small coloured halos, and that the air breathed is condensed in a visible manner. It may be permitted to doubt at least the latter fact; below 30° of latitude the cooling produced by the waters of the banks is not sufficiently considerable to cause this phenomenon. During the time we passed on the bank of the Vibora, the constitution of the air was quite different from what we found on quitting it. The rain was circumscribed by the limits of the bank, of which we could distinguish the form from afar, by the mass of vapors with which it was covered.

December 9th.—As we advanced towards the islands of the Caymans *, the north-east wind

* Christopher Columbus, in 1503, named the islands of the Caymans, *Penascales de las Tortugas*, on account of the sea-tortoises which he saw swimming in those latitudes (*Herera, Decad.*, i, p. 149).

again blew with the same violence. I obtained, notwithstanding the stormy weather, some heights of the sun, at the moment when we believed ourselves, though twelve miles distant, in the meridian of the center of the Great Cayman, which is covered with cocoa-trees. I have discussed in another place *, the position of the Great Cayman and the two islands on the east. Those points have long wandered on our hydrographic charts, and I fear that I have not been more fortunate than other observers, who flattered themselves they had made known its real position. The fine maps of the *Deposito de Madrid*, have, at different periods, marked the eastern cape of the Great Cayman, (in 1799-1804), long. 82° 58′; (in 1809), 83° 40′; (in 1821), again 82° 59′. The latter position, indicated on the map of M. Barcaiztegui, is identical with that on which I fixed; but it now appears certain, from the assertion of a very able navigator, Rear-Admiral Roussin, to whom we owe an excellent work on the coast of Brazil, that the western cape of Grand Cayman is in long. 83° 45′.

The weather continued bad, and the sea ex-

* *Obs. Astr., Int.*, p. xliii, Vol. ii, p. 114. *Espinosa, Memorias*, Vol. ii, p. 66. Purdy's map of the Antilles, rectified by Captain Andrew Livingston (1823), gives the cape on the S. W. 83° 52′; and on the N.E. 83° 24′.

tremely rough. The thermometer kept up between 19.2°-20.3° (15.4°-16.2° R.). At this low temperature the smell of the dried meat with which the vessel was laden, became still more insupportable. The sky displayed two beds of clouds, the lower was thick and pushed with extreme rapidity towards the S.E., the upper motionless, and divided at equal distance, in the form of feathered stripes. The wind at length was calmed on nearing cape Saint Antoine. I found the northern extremity of the cape 87° 17′ 22″, or 2° 34′ 14″ eastward of the Morro of the Havannah: this is the longitude now marked on the best maps. We were at the distance of three miles from land, but the proximity of the island of Cuba was announced by a delicious aromatic odour. The sailors pretend that this odour is not perceived when they approach from cape Catoche, on the barren coast of Mexico. As the weather grew clearer, the thermometer rose gradually in the shade to 27°: we advanced rapidly towards the north, pushed on by a current* from south-south-east, of which the temperature rose at the surface of the water, to 26.7°; while out of

* Diego Columbus had very precise ideas on the existence and the direction of the Gulf-stream; see *Petrus Martyr, Ocean*, Dec. 3. Lib. x, p. 326, 327; and *Herera*, Dec. 1, Lib. ix, p. 251.

the current, it was 24.6°. Fearing to go to the east of the Havannah, we at first wished to ascertain the islands of Tortoises *(Dry Tortugas)*, situated at the south-west extremity of the peninsula of Florida; but the confidence which the making of the land at cape Saint Antoine had inspired for the chronometer of Louis Berthoud, rendered that precaution unnecessary. We anchored in the port of the Havannah, the 19th December, after twenty-five days of navigation in constantly bad weather.

The whole surface of the archipelago of the West Indies contains near 8300 square leagues (20 to a degree), of which the four great islands Cuba, Haiti, Jamaica, and Portorico occupy 7200, or near nine-tenths. The area of insulary equinoxial America is consequently nearly equal to that of the Prussian monarchy, and twice as large as the *area* of the state of Pensylvania. Its *relative population* differs little from that of the latter state, and is three times less than that of Scotland *. I have been occupied during several years in researches to ascertain the number of inhabitants of different castes and colours which a fatal developement of colonial industry has assembled in the West Indies. This problem is linked so nearly to the misfortunes of the African race, and the dan-

* *See* above, Vol. vi, p. 341.

gers to human civilization in the strange assemblage of so many various elements, that I would not confine myself to collecting what is found scattered in printed works. I consulted by an active correspondence the respectable and enlightened men, who took an interest in my labors, and rectified the first results I obtained. I testify with pleasure my warm gratitude to Lord Holland, Mr. Charles Ellis, Mr. Wilmot, under-secretary of state in the department of the colonies, Mr. Allen, General Macauley, Sir Charles Mac-Carthy, late governor of Sierra Leone, Sir James Mackintosh, Mr. Clarkson, Mr. David Hodgson, and Mr. James Cropper of Liverpool.

POPULATION OF THE WEST INDIES (AT THE CLOSE OF 1823.)

Names of the Islands.	Total Population.	Slaves.	Observations and Variations.
I. ENGLISH WEST INDIA ISLANDS.	776,500	626,800	The total population of the English West India islands was estimated in 1788, at 528,302, of which 454,161 were slaves. Bryan Edwards, in 1791: slaves, 455,684; whites, 65,305; free coloured population, 20,000. Colquhoun, in 1812: total 732,176; slaves, 634,096; free coloured population, 33,081; whites, 64,994. Melish: 673,070, of which 70,430 were whites, and 607,640 slaves. Persons belonging, in 1823, to the congregation of *methodists*, in the English islands, 23,127 blacks, and men of colour, and 8476 whites. (*Debates of May* 15, 1823, p. 180.)
a) JAMAICA	402,000	342,000	In 1734, slaves, 86,146; whites, 7644; in 1746, slaves, 112,428; whites, 10,000; in 1768, slaves, 176,914; whites, 17,947; in 1775, slaves, 190,914; whites, 18,500; in 1787, slaves, 250,000; whites, 28,000; in 1791, whites, 30,000; free men of colour, 10,000; slaves, 250,000; in 1800, slaves, 300,939; in 1810, slaves, 320,000; in 1812, slaves, 319,912; in 1815, slaves, 313,814; in 1816, slaves, 314,038; free, 45,000; in 1817, slaves, 345,252. (Ancient reports give for 1658, slaves, 1400; whites, 4500; for 1670, slaves, 8000; whites, 7500; for 1673, slaves, 9504.) From 1770 to 1786, 610,000 negro-slaves were imported to Jamaica, of whom one-fifth were re-exported to other islands; there remained therefore in the island 488,000. (*Bryan Edwards*, Vol. ii, p. 64.) From 1787 to 1808, 188,785 more were imported; altogether, in 108 years, 676,785 negroes; and yet there exists at Jamaica but the half of that number, less than 350,000. (*Hatchard, Review of Registry Laws*, p. 74. *Cropper, Letters to Mr. Wilberforce*, 1822, p. 19, 29,

Names of the Islands.	Total population.	Slaves.	Observations and Variations.
			40.) Other estimates make the importation of the Africans to Jamaica since the conquest, amount to 850,000. (*East and West India sugar*, 1823. p. 34. *James Cropper, Relief for West Indian Distress*, 1823, p. 13. *Wilberforce, Appeal to Religion, Justice, and Humanity*, 1823, p. 49.) The population of the free men of colour is generally estimated too low. Mr. Stewart, who resided twenty years in that island (till 1820), supposes it to be 35.000, and the number of whites, 25,000. According to the *Official Registers*, which I owe to the obliging communication of Mr. Wilmot, in 1817; slaves, 343,145; in 1820, slaves, 341,812. In the last 14 years, on a slave population of 342,000, scarcely 600 marriages (257 a year) were legally contracted. (*Subst. of the Debate of the House of Commons*, 1823, p. 164.)
b) BARBADOES - -	100,000	79,000	Mr. Morse estimates the total population in 1786 at 79;220; in 1805, slaves, 60,000; free men, 17,130; in 1811, according to a numeration believed to be very exact, slaves, 79,132; free coloured population, 2613; whites, 15,794. In 1823, probably 16,000 whites; free men of colour, of which the number augments greatly, 5000. Total population, perhaps 100,000. According to the *Official Registers*, in 1817, slaves, 77,493; in 1820, slaves, 78,345.
c) ANTIGUA - -	40,000	31,000	In 1815, slaves, 36,000; free, 4000; in 1823, probably free-coloured population, 4000: whites, 5000. According to the *Official Registers* of 1817, slaves, 32,269; in 1820, slaves, 31,053.
d) SAINT CHRISTOPHER, OR SAINT KITTS - - -	23,000	19,500	In 1791, slaves, 20,435; whites, 1900; in 1805, slaves, 26,000; whites, 1800; free men of colour, perhaps 2500. Accord-

Names of the Islands.	Total population.	Slaves.	Observations and Variations.
			ing to the *Official Registers*, slaves, 20,137; in 1820, slaves, 19,817.
e) NEVIS - - -	11,000	9,500	In 1809, total 9300, of whom 8000 were blacks (Chalmers); in 1812, total, 10,430, of whom 9326 were slaves. (*Offi. Reg.* of 1817; slaves, 9603; of 1820, slaves, 9261; free men of colour, nearly 1000; whites, 450.
f) GRENADA -	29,000	25,000	In 1791, according to Bryan Edwards, slaves, 23,926; whites, 1000; in 1815, slaves, 29,381; free, 1891. *Offi. Reg.* of 1817, slaves, 28,024; of 1820, slaves, 25,677; free men of colour, now, nearly 2800; whites, 900.
g) SAINT VINCENT AND THE GRENADINES - - - -	28,000	24,000	In 1791, slaves, 11,853; whites, 1450; in 1812, total, 27,455, of whom 22,920 were slaves; in 1815, total 23,493, among whom 2130 were free. *Offi. Reg.* of 1817, slaves, 25,255; of 1820, slaves, 24,252.
h) DOMINICA - -	20,000	16,000	In 1791, slaves, 14,967; whites, 1236; in 1805, slaves, 22,083; free, 4416; in 1811, total, 25,031, of whom 1325 were whites; free coloured population, 2988; slaves, 21,728. The relative number of the blacks or free mulattoes, and the whites, is here, as every where else, extremely uncertain; the former are now perhaps the double of the latter in number. *Offi. Reg.* of 1817, slaves, 17,959; of 1820, slaves, 16,554. Slaves are often exported from Dominica and the Bahama islands to Demerara, where the climate causes a terrible mortality, even among the free coloured population, that are not inured to the climate.
i) MONTSERRAT -	8,000	6,500	In 1805, slaves, 9500; free, 1250; in 1812, slaves, 6534; free, 442. *In 1823,*

Names of the Islands.	Total population.	Slaves.	Observations and Variations.
			according to the most correct opinions, 1500 free, of whom scarcely one-fifth are whites. *Offi. Reg.* 1817, slaves, 6610; of 1820, slaves, 6505. Mr. Morse estimates the total population in 1822, at 10,750; but it is not so great.
k) English Virgin Islands, Anegada, Virgin Gorda and Tortola	8,500	6,000	Very uncertain. In 1820, probably, slaves, 6000; free men of colour, 1200-1500; whites, 400. In 1788, however, the slaves were estimated at 9000. (Melish reckoned in 1822, the total population at Tortola to be 10,500; and at Virgin-Gorda, 8000!)
l) Tobago - - -	16,000	14,000	In 1805, slaves, 14,883; free, 1600; in 1811, slaves, 16,897; free, 935; in 1815, total, 18,000. *Offi. Reg.* of 1817, slaves, 15,470; of 1820, slaves, 14,581 [probably now 2000 free, of whom 1200 are coloured population.] Mr. Morse (*Modern Geogr.*, p. 236,) reckons for 1822, total 16,483, of whom 15,583 were slaves and free men of colour, and 900 whites.
m) Anguilla and Barbuda - -	2,500	1,800	Uncertain.
n) Trinidad - -	41,500	23,500	In 1805, slaves, 19,709; free, 5536 (M^{c} Cullum). Numeration of 1811, believed to be very exact; total 32,989, of which 2617 were whites; free men of colour, 7493; free Indians, 1736; slaves, 21,143. *Offi. Reg.* of 1817, slaves, 25,941; in 1820, slaves, 23,537. It is usual to estimate much too low the constantly increasing population of this island. Mr. Morse, in 1822, total 28,477; yet there is no doubt of there being now at least 14,000 free men of colour; whites, 4000; slaves, nearly 24,000.
o) Saint Lucie -	17,000	13,000	In 1788, the total was estimated at 20,968, of whom 17,221 were slaves; in

Names of the Islands.	Total population.	Slaves.	Observations and Variations.
			1810, total 17,485, of whom 14,397 were slaves; free men of colour, 1878; whites, 1210. *Offi. Reg.* of 1817, slaves, 15,893; of 1820, slaves, 13,050.
p) BAHAMA ISLANDS	15,500	11,000	Partly beyond the limits of the torrid zone. In 1810, total 16,718, of whom 11,146 were slaves. (Now probably 11,000 slaves; free coloured population, 2500-3000; whites, 1500.)
q) BERMUDAN ISLANDS - - -	14,500	5,000	Small archipelago, situated in the temperate zone, and far distant from the rest of insulary America. In 1791, total 10,780, of whom 4919 were slaves; in 1812, total 9900, of whom 4794 were slaves.
II. HAITI, FRENCH AND SPANISH - -	820,000		Mr. Necker, in 1799, admitted in the *French part*, total 288,803; in 1788, total 520,000, of whom 40,000 were whites; freedmen, 28,000; slaves, 452,000; in 1802, Mr. Page estimated the total population at only 375,000, of whom 290,000 were labourers. In 1819, according to the observation of General Pamphile-Lacroix, the *French part* contained 501,000, of whom 480,000 were blacks, 20,000 mulattoes, and 1000 whites; *Spanish part*, 135,000, of whom 110,000 were blacks, and 25,000 whites. General Macaulay, whose researches always bear the character of philanthropy and the love of truth, thinks that the total population of Haïti exceeds 750,000, among whom, in the *French part*, 600,000 were negroes and mulattoes, and 4000 whites; in the *Spanish part*, 120,000 negroes and mulattoes, and 26,000 white creoles. In the *French part*, the number of mixed blood, 24,000. The last *official numeration* yields 935,335, among whom, in the circle of Jacmel only, 99,408; of Port au Prince,

Names of the Islands.	Total population.	Slaves.	Observations and Variations.
			89,164; of Cayes, 63,536; of Aguni, 58,587; of Leogane, 55,662; of Mirabalais, 53,649; of Nepper, 44,478; of the Cape Haïtian, 38,566; of Tiburon, 37,927. of Jeremy, 37,652; of Saint Mark, 37,628; of the Great River, 35,372; of Gonaïves, 33,542; of Lembé, 33,475; of Marmelade. 32,852; of Santo Domingo, 20,076. (*New Monthly Mag.*, 1825, *Feb.*, p. 69.) The precautions taken by the Haïtian government to obtain a precise result, are not known. Having always in my labors on political economy, prescribed to myself the rule of publishing the lowest numbers, I have diminished one-ninth the result of the official numeration. The limit-numbers are now 800,000 and 940,000. Very exaggerated assertions, connected with political views, have carried the population of Haïti to more than a million; it is certain that this population augments with extreme rapidity, and is favored by wise institutions.
II. SPANISH ISLANDS	943,000	281,400	According to an official document presented to the Cortes at Madrid, in 1821, total 630,980, of whom 290,021 were whites; free coloured population, 115,691; slaves, 225,268. *Reclamacion hecha por los representantes de la Isla de Cuba, contra los aranceles*, p. 7. The number of slaves imported, from 1817-1819, was from 15,000 to 26,000. *Letters from the Havannah to John Wilson Croker, Esq.*, 1821, p. 18-36. These importations are frightful; even Rio Janeiro does not receive a greater number in these latter times; namely, 1821, slaves, 20,852; in 1822, slaves, 17,008; in 1823, slaves, 20,610; *Offic. Correspond. with the Brit. Commis.*, 1823, B., p. 109, 121. *Alexander Caldcleugh's Travels in South America*, 1825, Vol. ii, p. 266. (Mr. Melish, in his American Geography, gives the island of
a) CUBA - - -	700,000	256,000	

Names of the Islands.	Total population.	Slaves.	Observations and Variations.
			Cuba, in 1823, a population of only 435,000.)
b) PORTORICO	225,000	25,000	The total population in 1778, was estimated at 80,650; in 1794, at 136,000, of whom 15,000 were whites, 103,500 free men of colour, and 17,500 slaves. But the official numeration of 1822, gives with more certainty, for the total population 225,000, of whom 25,000 were slaves. (*Poinsett, Notes on Mexico; Philad.* 1824, p. 5). If the number of whites amounted only to 22,000, this numeration would yield 178,000 for free men of colour, an estimate which appears to me exaggerated when compared with the free men of colour of the whole island of Cuba.
c) MARGUERITA	18,000	400	M. de Ponce: 14,000, of whom 2000 were Indians.
IV. FRENCH ISLANDS	219,000	178,000	Freedmen, probably more than 25,000.
a) GUADALOUPE & ITS DEPENDENCIES. (SAINT MARIE-GALANTE LA DESIRADE, & PART OF ST. MARTIN)	120,000	100,000	In 1788, total 101,971, of whom 13,466 were whites; 3044 free men of colour; 85,461 slaves. From the official information, which I owe to Mr. Moreau de Jonnès, total in 1822, 120,000, of whom 13,000 were whites; free coloured population, 7000; slaves, 100,000. Other official documents give at Guadaloupe in 1821, total 109,404, of whom 12,802 were whites; free men of colour, 8604; slaves, 87,998.
b) MARTINIQUE	99,000	78,000	The total population in 1815, was believed to be 94,413, of whom 9206 were whites, 8630 men of colour, and 76,577 blacks. According to the official numeration of 1822, total 98,125, of whom 9660 were whites, 10,173 men of colour, and 76,914 slaves.

Names of the Islands.	Total population.	Slaves.	Observations and Variations.
V. Dutch, Danish, and Swedish Islands - - -	84,500	61,300	
a) Saint Eustache and Saba - -	18,000	12,000	No island presents greater uncertainty. M. Malte Brun (*Geogr.* Vol. v, p. 748) estimates the total population in 1815, at only 6400, of whom 5000 were whites, 600 free coloured men, and 800 slaves. But this number of whites is little probable. M. J. Van den Bosch (*Neder landsche Overzeesche Bezittingen*, 1818, Vol. ii, p. 232) fixes on 2400; while the new Geography of Mr. Morse, in general carefully executed (*New System of Modern Geography*, 1822, p. 249), has fixed on 20,000.
b) Saint Martin	6,000	4,000	*Morse, l. c.*, p. 248. One part is French, the other Dutch.
c) Curaçoa - -	11,000	6,500	Melish, 8500; Hassel, 14,000. Van den Bosch (Vol. ii, p. 227) for 1805, total population, 12,840. Dutch islands in general, 35,000, of whom 22,500 are slaves.
d) Saint-Croix -	32,000	27,000	In 1805, whites, 2223; freedmen, 1664; slaves, 25,452. Total, 29,339.
e) Saint Thomas	7,000	5,500	In 1815, whites, 726; freedmen, 239; slaves, 4769. Total, 5734.
f) Saint John -	2,500	2,300	In 1815, total, 2120, of whom, whites, 102; slaves, 1292. Mr. Hassel estimates the total population of the Danish islands, in 1805, at 38,695; Mr. Colquhoun estimates it in 1812, at 42,787, of whom 37,030 were slaves.
g) Saint Bartholomew - - -	8,000	4,000	*Morse*, p. 249.

The observations placed against the results which are now the most probable, contain some historical facts on the increasing progression of the population. These facts, of very unequal precision, are, however, only *variantes lectiones*, the expression of the opinion formed at particular periods, on the number of the inhabitants. Most frequently, they are not those differences, but the official registers of the last years, which have served for the basis of my calculations. When *registers* are wanting, we can only be guided by general considerations on the value of statistic results. In opinions which are contested with violence, and which affect the greatest interests of humanity, we must distrust the exaggeration of extreme parties, and take the mean between the estimates furnished by the planters, and those of associations formed with the view of diminishing the miseries of slavery. The comparison of the registers of different periods does not always furnish precise ideas of the mortality of the slaves in the colonies of different nations. There are countries in which the names of deceased slaves are given to those who are clandestinely introduced. When certain results cannot be obtained, much is gained by finding the *limit-numbers*; and being able to assert, that in the island of Jamaica, there are at least 342,000 slaves; at Barbadoes, 79,000, and at Guadaloupe, 100,000. The re-

sults furnished by the enumerating or registering of the slaves (*Slave Registry Returns*), afford only *limit-numbers*, the *minima* of particular periods. The proprietors have an interest in concealing a part of the slaves they possess; the effects of emancipation * are confounded on the registers with those of decease; and on the other hand a part of the births is hidden. The registers in general tend to prove, that hitherto (from 1817 to 1824) the black population decreases in the English colonies of the West Indies, and much more in the small islands than at Jamaica, and wherever the planters work with considerable capitals a soil producing alimentary subsistence in abundance. The official registers give for twelve English West India islands, in 1817, 617,799 slaves; for 1822, 604,444 slaves; from whence results a loss of 1-46th in three years. At Jamaica alone it was only 1-257th; and in the small islands it fluctuates from 1-12th to 1-60th. I do not give these statements as true, but as resulting from the *registers*. The distinction of whites, and free coloured population, presents such great difficulties, that at the end of the year 1823,

* *Adam Hodgson, Letter to M. Say*, 1823, p. 37. *Debate of the 15th May*, 1823, p. 184. *Bridges on Manumission and Negro Slavery of the United States and Jamaica*, 1823, pp. 51 and 85.

the Colonial Office was in possession of no precise information on that important point. But the English government has recently, with the most laudable purpose, employed means fitted to solve this problem, connected more than any other with the ideas of public security. The free negroes at the Havanah, form 5-13ths, or 38 per cent; but their number in general can only be estimated at 2-5ths. The estimate of free men is not less uncertain in some colonies than that of slaves. There are some individuals who enjoy full liberty, but a liberty not legally recognized.

In the registers that indicate the population of the islands, the words *blacks* and *slaves* are generally taken for synonimous. There exists, however, among the slaves, a small number of mulattoes, and others of mixed race. I believe their number amounts at most to 1-20th; and I calculated according to this supposition, the number of the negro slaves in the table of the black population of America. The numeration of the island of Cuba furnishes a more considerable result; that of 1-10th to 1-12th in the town of Havannah. It possessed in 1810, on a slave population of 28,700, *pardos esclavos*, 2300; *morenos esclavos*, 26,400. The great towns in the Spanish islands are characterized by this accumulation of mulattoes and slaves of mixed race.

With respect to the population of the island of Saint Domingo (Haiti) I believe I have fixed on an estimate sufficiently low. We possess partial statements of the official numeration, circle by circle; and considerations founded on positive calculations lead us to conclude that the population of Haiti may now attain 820,000. Mr. Pagé, after the calamities of the colony in 1802, estimated both parts, French and Spanish, at 500,000. Now, supposing r or the rate of annual increase to be only 0.016 (which doubles in forty-four years), I find for 1822, a population of 686,800. If we admit a more rapid increase, similar to that of the slave population in the southern part of the United States (r=0,026, consequently a doubling in 27 years) we obtain for 1822 a population of 835,500; but how can it be believed that Mr. Pagé has not estimated the population of 1802 too low? Necker admitted in 1788, 520,000 in the French part, and 620,000 in the whole island of Saint Domingo. Many years of peace and tranquillity have succeeded that period, interrupted by some of disorder and carnage. Even the maroon-negroes of Jamaica have augmented, deducting from the number the fugitive slaves who join them occasionally. It is more natural to admit that, in an interval of fourteen years (from 1788 to 1802,) the population has been preserved at 600,000, notwithstanding the civil

wars and emigration; and, admitting this statement, we find, according to the two hypotheses ($r = 0{,}016$, or $r = 0{,}026$), 824,200, or 1,002,500. The last official numeration, published by the government of Haïti, gives 935,300: in order to avoid exaggeration, I fixed on 820,000.

BLACK POPULATION OF CONTINENTAL AND INSULARY AMERICA.

1. *Negro Slaves.*

West India insulary America	1,090,000
United States	1,650,000
Brazil	1,800,000
Spanish Colonies of the Continent	307,000
English, Dutch and French Guyanas	200,000
	5,047,000

2. *Free Negroes.*

Haïti, and the other Islands	870,000
United States	270,000
Brazil, perhaps	160,000
Spanish Colonies on the Continent	80,000
English, Dutch, and French Guyanas	6,000
	1,386,000

RECAPITULATION.

Blacks without mixture, consequently excluding mulattoes:

5,047,000 slaves	79 per cent.
1,386,000 free	21
6,433,000	

The habit of living in countries where the whites are so numerous as in the United States, has had a singular influence on the ideas which have been formed of the preponderance of different races in various parts of the New Continent. The number of negroes and of mixed race, which amount together, in my tables, to more than 12,861,000, or to 37 per cent., has been arbitrarily diminished; while the white population does not exceed 13½ millions, or 33 per cent. Mr. Morse admitted for the whole of America, in 1822, 50-100th whites, 33-100th Indians, 11-100th negroes, and 5-100ths of mixed race. MM. Carry and Lea suppose a population of 2,050,000 in the archipelago of the West Indies, of which 450,000 whites, and 1,600,000 blacks and mulattoes; this indicates 22 per cent. of whites. We have just seen that the statement is still a little more unfavourable, and that on the total population of the West Indies, 2,843,000, there are 17 per cent. of whites, and 83 per cent. of men of colour, slaves and free; that is, that the whites are to the men of colour = 1 : 5.

DIVISIONS.	TOTAL POPULATION.	BLACK SLAVES, and some Mulattoes.	FREE MEN of colour, Mulattoes, & Blacks.	WHITES.
Spanish West Indies	943.000	281·400	319.500	342.100
Haïti	820.000	.....	790.000	30.000
English Islands.....	776.500	626.800	78.350	71.350
French Islands	219.000	178.000	18.000	23.000
Dutch, Danish, and Swedish Islands	84.500	61.300	7.050	16.150
Total of the West Indies	2.843.000	1.147.500 (40 p. c.)	1.212.900 (43 p. c.)	482.600 (17 p. c.)

DISTRIBUTION OF THE RACES IN SPANISH AMERICA.

1. *Natives.* (Indians, red men; copper-coloured American, or primitive race, without mixture of white, and negro.)

Mexico	3,700,000
Guatimala	880,000
Columbia	720,000
Peru and Chili	1,030,000
Buenos Ayres, with the Provinces of Sierra	1,200,000
	7,530,000

2. *Whites.* (Europeans, and descendants of Europeans, without mixture of Negro and Indian, the pretended race of Caucasus.)

Mexico	1,230,000
Guatimala	280,000
Cuba and Portorico	339,000
Columbia	642,000
Peru and Chili	465,000
Buenos Ayres	320,000
	3,276,000

3. *Negroes.* (African race, without mixture of white or Indian, blacks, free and slaves.)

Cuba and Portorico	389,000
Continent	387,000
	776,000

4. *Black, white, and Indian mixed races.* (Mulattoes, Mestizos, Zambos, and mixture of mixtures.)

Mexico	1,860,000
Guatimala	420,000
Columbia	1,256,000
Peru and Chili	853,000
Buenos Ayres	742,000
Cuba and Portorico	197,000
	5,328,000

RECAPITULATION,

ACCORDING TO THE PREPONDERANCE OF THE RACES.

Indians	7,530,000	or 45 per cent.
Mixed races	5,328,000	32
Whites	3,276,000	19
Blacks, African race	776,000	4
	16,910,000	

DISTRIBUTION OF THE RACES IN CONTINENTAL AND INSULARY AMERICA.

1. *Whites.*

Spanish America	3,276,000
West Indies, without Cuba, Portorico, and Marguerita	140,000
Brazil	920,000
United States	8,575,000
Canada	550,000
English, Dutch, and French Guyanas	10,000
	13,471,000

2. *Indians.*

Spanish America	7,530,000
Brazil (inclosed Indians of Rio Negro, Rio Branco, and the Amazon)	260,000
Independent Indians, on the east and west of the Rocky Mountains, on the frontiers of New Mexico, the Mosquitos, &c.	400,000
Independent Indians of South America	420,000
	8,610,000

3. *Negroes.*

West Indies, with Cuba and Portorico	1,960,000
Continent of Spanish America	387,000
Brazil	1,960,000
English, Dutch, and French Guyanas	206,000
United States	1,920,000
	6,433,000

4. *Mixed races.*

Spanish America	5,328,000
West Indies, without Cuba, Portorico, and Marguerita	190,000
Brazil and the United States	890,000
English, Dutch, and French Guyanas	20,000
	6,428,000

RECAPITULATION.

Whites	13,471,000	or 38 per cent.
Indians	8,610,000	25
Negroes	6,433,000	19
Mixed race	6,428,000	18
	34,942,000	

A calculation founded on the numeration of 1810 and 1820, gives (the rate of the increase = 0,02611) at the end of 1822, at least 1,623,000 slaves in the United States (*See* above, pp. 140, and 369, and *Sixteenth Report of the African Institution*, p. 324); and at the end of 1824, at least 1,708,300. The free men of colour were, in 1820, more than 238,000. In the two colonies of Demerara and Essequibo, 71,180 slaves were computed in 1811; free men of colour, 2980; whites 2871; total 77,131. Total population at Berbice, 25,959, of which 550 whites, 240 free men of colour, and 25,169 negro slaves. Total population of Demerara, Essequibo, and Berbice for 1811, above 103,000, of which more than 96,000 slaves. According to J. Van den Bosch (Vol. ii, p. 114), there were at Demerara in 1814, 47,132 slaves; at Essequibo, 16,187; and at Berbice, 22,223; total 85,442 slaves. General Macaulay believed the population of Demerara to be in 1823, 83,900, of which 77,400 slaves, 3000 free men of colour, and 3500 whites. He admitted for Berbice, 25,430, of whom 23,180 slaves, 1500 free men of colour, and 750 whites. The *official registers* communicated by Mr. Wilmot, give for the colony of Demerara in 1817, 77,867 slaves; in 1820, 77,376; the colony of Berbice in 1817, slaves 23,725; and in 1820, 23,180 slaves. It appears probable that the English, Dutch, and French Guyanas now contain more than 236,000 slaves. French Guyana reckoned in 1821, a total of 16,000, without Indians; namely, 12,000 slaves, 1000 whites, and 3000 free men of colour. According to the official documents, it contained (1st January 1824) 1035 whites, 1923 free men of colour, 701 Indians, and 13,656 slaves; total 17,315. The number of blacks spread over the vast continent of Spanish America, is so small (below 390,000), that, happily, they do not form 2½ per cent of the continental population. Salutary changes are preparing in the condition of the slaves. According to the laws that govern the new independent

states, slavery will be extinguished by degrees: the republic of Columbia has given the example of progressive liberation. That measure, at once humane and prudent, is due to the disinterestedness of General Bolivar, whose name is not less illustrious by the virtues of the citizen, and by his moderation in success, than by the splendour of his military glory.

DISTRIBUTION OF THE TOTAL POPULATION OF AMERICA, ACCORDING TO THE DIVERSITY OF RELIGIOUS WORSHIP.

I. *Roman Catholics*		22,486,000
a Continental Spanish America	15,985,000	
Whites	2,937,000	
Indians	7,530,000	
Mixed & negro race	5,518,000	
	15,985,000	
b Portuguese America	4,000,000	
c United States, Lower Canada, and French Guyana	537,000	
d Haïti, Cuba, Portorico, and French West Indies	1,964,000	
	22,486,000	
II. *Protestants*		11,636,000
a United States	10,295,000	
b English Canada, New Scotland, Labrador	260,000	
c English and Dutch Guyana	220,000	
d English West India Islands	777,000	
e Dutch and Danish Islands, &c.	84,000	
	11,636,000	
III. *Independent Indians, not Christians*		820,000
		34,942,000

This statement furnishes only the great divisions of the Christian communities. I believe that the materials I possess* on the relative state of the Roman Catholics and Protestants are sufficiently exact, but I shall not enter into the detail of the divisions of the protestant or evangelical [Calvinistic] church. A few partial estimates, for instance, of the number of catholics in Louisiana, Maryland, and Lower Canada, are perhaps somewhat uncertain; but that uncertainty affects quantities which have but a feeble influence on the definitive result. I believe that the number of protestants in the whole of continental and insulary America, from the southern extremity of Chili to Greenland, is, to the Roman Catholics, as 1 : 2. There exist, on the western coast of North America, some thousands of individuals who follow the Greek worship. I am ignorant of the number of Jews spread over the surface of the United States, and in several of the West India islands; but their number is inconsiderable. The independent Indians, who belong to no Christian community, are to the Christian population as 1 : 42. In the present state of

* These materials first appeared in the *Revue Protestante*, No. 3, p. 97. (See my Letter to Mr. Charles Coquerel.) More precise notions on the population of Cuba, Haïti, and Portorico, have led to some corrections in the partial statements.

things, the Protestant population augments much more rapidly in the New World than the catholic; and it is probable that, notwithstanding the state of prosperity to which independence, the progress of reason, and free institutions will raise Spanish America, Brazil, and the island of Haiti, the relation of 1 to 2 will, in less than half a century, be considerably modified in favour of protestant communities. Admitting a total population in Europe of 198 millions, we may compute nearly 103 millions of Roman Catholics, 38 millions who follow the Greek worship, 52 millions of Protestants, and 5 millions of Mahometans. The numerical relation of the Protestants to the members of the Roman Catholic and Greek churches, is consequently, by approximation, as $1 : 2\frac{7}{10}$. This relation between the Protestants and Roman Catholics is the same in Europe and in America. The tables we collect at the end of this chapter, have a close connexion with each other; for in every zone, the difference of race and origin, the individuality of language, and the state of domestic liberty, have a powerful influence on the dispositions of men for particular forms of worship.

PREPONDERANCE OF THE LANGUAGES IN THE NEW CONTINENT.

1. *English language.*	
United States	10,525,000
Upper Canada, New Scotland, New Brunswick	260,000
West Indies, and English Guyana	862,000
	11,647,000
2. *Spanish language.*	
Spanish America, namely,	
Whites	3,276,000
Indians	1,000,000
Mixed and negro race	6,104,000
Spanish part of Haïti	124,000
	10,504,000
3. *Indian tongues.*	
Spanish and Portuguese America, comprehending the independent tribes	7,593,000
4. *Portuguese language.*	
Brazil	3,740,000
5. *French language.*	
Haïti	696,000
Islands dependent on France, Louisiana, and French Guyana	256,000
Lower Canada, and some tribes of independant Indians	290,000
	1,242,000

6. *Dutch, Danish, Swedish and Russian languages.*

West Indies	84,000
Guyana	117,000
Russia, on the N. W. coast	15,000
	216,000

RECAPITULATION.

English language	11,647,000
Spanish	16,504,000
Indian	7,593,000
Portuguese	3,740,000
French	1,242,000
Dutch, Danish and Swedish	216,000
	34,942,000
Languages of Latin Europe	15,486,000
Languages of Germanic root	11,863,000
European languages	27,349,000
Indian languages	7,593,000

I have not mentioned separately the German, the Gaelic (Irish) and the Basque, because the numerous individuals who preserve the knowledge of those mother-tongues, understand also English or the Castillian. The number of individuals who usually speak the Indian languages, is at present as $1 : 3\frac{2}{5}$ to the number who employ the languages of Europe. By the more rapid increase of the population of the United States, the languages of the German

branch will gain insensibly in the numerical relation over the languages of Latin Europe; but the latter will spread at the same time, by the effect of the increasing civilization of the nations of Spanish and Portuguese race in the Indian villages, where scarcely a twentieth part of the population understand a few Castillian and Portuguese words. I believe there still exist more than seven millions and a half of natives in America, who have preserved the use of their own language, and are almost entirely ignorant of the European idioms. Such is also the opinion of the Archbishop of Mexico, and of several ecclesiastics alike respectable, who long inhabited Upper Peru, and whom I was enabled to consult on this subject. The small number of Indians (perhaps a million) who have entirely forgotten their native languages, inhabit large towns, or very populous villages in their vicinity. Among the individuals who speak French in the New Continent, we find more than 700,000 negroes of African race, a circumstance which, notwithstanding the laudable efforts of the Haitian government for popular instruction, does not contribute to maintain the purity of the language. We may admit in general, that in continental and insulary America, there are, in 6,433,000 blacks, more than 25-100ths who speak English, more than 30-100ths who speak Portu-

guese, and more than 14-100ths and 12-100ths who speak French and Spanish.

These statements of population, considered in their relations with the differences of race, languages, and worship, are composed of very variable elements, and represent approximatively the state of American society. In a work of this kind, we can take into consideration only great masses; the partial estimates may in time acquire more rigorous precision. The language of cyphers, the sole hieroglyphics which have been preserved among the signs of thought, stands in no need of interpretation. There is something serious and prophetic in these inventories of the human race: in them the whole future destiny of the New World seems to be inscribed.

W. Pople, Printer,
67, Chancery Lane.

00088186

Digitized with financial assistance from the
Government of Maharashtra
on 04 April, 2016